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AN ANALYSIS OF SPARE PARTS FORECASTING METHODS UTILIZED IN THE UNITED STATES MARINE CORPS

by

Robert E. Love

and

Byron F. Stebbins

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Thesis Advisor: Dale I. Scoggin

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(2) The current inventory is inadequate and state of the art methods and models should be implemented by the Marine Corps.

(3) Contractor provided engineering estimates tend to be skewed. Provisioners have no formal method for validating contractor data.

One major contribution of this study is the development of an initial manual of standard factors that can be used by provisioners to validate data and as a baseline from which pertinent questions could be raised.

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by

Robert E. Love
Captain, United States Marine Corps
B.S., State University of New York at Albany, 1977

and

Byron F. Stebbins
Captain, United States Marine Corps
B.B.A., Texas A&M University, 1978

Submitted in partial fulfillment of the requirements for the degree of

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June 1987

Authors: Robert E. Love
Robert E. Love

Byron F. Stebbins
Byron F. Stebbins

Approved by: Dale I. Scoggin
Dale I. Scoggin, Thesis Advisor

Nancy C. Roberts
Nancy C. Roberts, Second Reader

Willis R. Greer, Jr., Chairman,
Department of Administrative Sciences

Kneale T. Marshall
Kneale T. Marshall,
Dean of Information and Policy Science

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One major contribution of this study is the development of an initial manual of standard factors that can be used by provisioners to validate data and as a baseline from which pertinent questions could be raised.

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I. INTRODUCTION

A. GENERAL

The early 1980's saw a dramatic increase in the number of weapons systems being fielded within the Department of Defense (DOD). By 1982 total DOD outlays had increased to approximately 200 billion dollars, the highest level since the height of the VietNam conflict (1968). For the first time in nearly 14 years the DOD had sufficient funds to modernize and maintain its forces [Ref. 1:p. 17].

Along with the increased funding came the burden of managing the dynamic provisioning process. Unfortunately the services were inadequately prepared to meet the challenge. By 1983 horror stories abounded of government procurement of overpriced spare parts. The DOD's internal audit agency uncovered numerous instances where DOD contractors had overcharged Navy and Air Force contracting activities [Ref. 2]. A popular example was the procurement of a 4 cent diode for which the DOD had paid 110 dollars [Ref. 3:p. 10]. While overpricing received considerable congressional attention, other problems in the provisioning process remained unsolved.

Provisioning is a method used to acquire support for the initial spare parts necessary to field a weapons system (when it first becomes operational) prior to the development

of sufficient usage data to meet the inventory stockage criteria [Ref. 4:p. 313]. For the purpose of this thesis the term spare parts will be used in a general sense. In other words, spare parts is defined as material that is acquired for the purpose of maintaining, overhauling and repairing a piece of equipment. This definition includes such terms as repair parts, spares, parts, subassemblies, components and subsystems. Excluded are major end items such as tanks, trucks, aircraft and the like [Ref. 4:p. 10].

Initial provisioning is generally based on the estimated maintenance factors provided in the Logistics Support Analysis (LSA). Estimated maintenance factors include but are not limited to replacement rates, failure rates, repair times, and leadtimes. These estimates are provided to the military service by the contractor. They can be based on engineering estimates or past experience for a similar component [Ref. 4:p. 313]. The estimates are used in the appropriate inventory model to establish stockage levels, requisitioning objectives, reorder points and the like. Because maintaining any type of inventory incurs expenses, the benefits of holding inventory must equal or exceed the holding and ordering costs.

The two fundamental issues in controlling any inventory are when to order and how much to order. When the demand for an item is uncertain, as in the case of initial provisioning, a level of safety stock must be carried to

meet unpredicted demand [Ref. 5:p. 2]. Low stock levels result in low customer service and high ordering costs. High stock levels increase the customer service level while decreasing ordering costs. By maintaining high stockage levels, however, we experience increased storage costs, as well as costs associated with obsolescence and deterioration. In general, when stock and service levels rise, holding costs will increase while ordering costs decrease [Ref. 5:p. 20]. Holding costs and production leadtimes play major roles in the determination of stockage levels. A poor estimate of leadtime can lead to the maintenance of an inappropriate level of inventory and, hence, increased cost.

B. OBJECTIVES OF THE RESEARCH

The objectives of this research are twofold: 1) to identify and examine the existing methodologies and critical factors that affect the initial provisioning stockage levels in the Marine Corps; 2) to identify actions that can be taken to enhance the current provisioning process at the Marine Corps Logistics Base (MCLB) Albany, Georgia.

C. RESEARCH QUESTIONS

In pursuing the objectives of the research, the following research question is posed:

Are the present forecasting techniques used by the United States Marine Corps to determine spare parts

provisioning viable?

Additionally, the following subsidiary research questions were developed to assist in answering the primary research question:

1. Are the factors used for calculating range and depth for wholesale system stock adequate?

2. Can other services' provisioning techniques benefit current Marine Corps practices?

3. Is contractor furnished provisioning data sufficient for determining procurement quantities?

4. Does contractor forecasted provisioning data reflect actual performance and usage data?

5. How can the current scope and methodology of provisioning at MCLB Albany be expanded and improved?

D. RESEARCH METHODOLOGY

The research methodology utilized in this study involves a comprehensive review of available literature to include current governmental regulations. Additionally, personal and telephone interviews were conducted with government personnel actually involved in the provisioning of spare parts, both from an operational and a policy perspective.

The literature utilized in the study was obtained through the Naval Postgraduate School; Defense Logistics Studies Information Exchange (DLSIE); the Defense Technical Information Center (DTIC); Headquarters, United States Marine Corps; and the Marine Corps Logistics Base, Albany.

Personal interviews were conducted with contracting, technical and logistics personnel at MCLB, Albany.

Additionally, personal interviews were conducted with academic logistics professionals at the Naval Postgraduate School, Monterey. Telephone interviews were conducted with provisioning personnel at the Office of Installations and Logistics, Headquarters, United States Marine Corps; the Weapons Systems Directorate, MCLB Albany; and appropriate logistics personnel of the U.S. Army; U.S. Navy; and the U.S. Air Force.

E. SCOPE OF THE STUDY

The main thrust of this study is centered around the logistical concept for the provisioning of spare parts. The research focuses primarily on the factors utilized to establish initial spare parts stockage levels at the Marine Corps Logistics Base Albany, Georgia.

The study focuses on initial provisioning of spare parts. Replenishment spare parts as a distinct process was considered only as it relates to initial provisioning.

It is assumed that the reader is familiar with standard acquisition concepts and terminology as well as the spare parts procurement process.

F. DEFINITIONS

Appendices A and B are provided to assist the reader in understanding the multitude of acronyms, abbreviations and terms used throughout this thesis. In addition to the terms contained in the appendices, the following definitions are

considered essential to the conceptual and operational presentations in this study:

1. **Spare Parts:** The term spare parts identifies material that is acquired for the ultimate purpose of maintaining, overhauling, and repairing weapons systems and equipment [Ref. 6:pp. 2B3-2B10]. Replenishment spare parts are consumable or repairable parts purchased after provisioning of that part for replacement, replenishment or use in the maintenance, overhaul, and repair of equipment [Ref. 8:S6-102.11]. The USMC has two basic types of appropriations to fund for procurement, stocking and issue of spare parts:

   The Procurement Marine Corps (PMC) is a multi-year appropriation intended for funding of investment type items to include spare parts (investment spares). Repairable, nonconsumable items are considered investment items and as such, their procurement, either wholesale or retail, is financed using PMC funds.

   The Operations and Maintenance, Marine Corps (OMMC) fund is used for the financing of spare parts to meet depot, garrison, and field spare part requirements (expense spares). At the wholesale level the Marine Corps uses a revolving type fund account known as the Stock Fund to procure parts from suppliers.

   The Marine Corps Logistics Base Albany is designated as the USMC's Primary Inventory Control Activity (PICA) and is the wholesale manager for approximately 1,990 depot repairable components (investment spares) and over 9,000 repair parts (expense spares) [Ref. 7].

2. **Data Repository:** A DOD entity responsible for receiving, cataloging, storing and retrieving technical data [Ref. 9:App. B].

G. ORGANIZATION OF THE STUDY

Chapter II provides background information concerning DOD policies and the basic provisioning processes of the U.S. Marine Corps and the U.S. Navy.

Chapter III describes the principle methodologies available to the USMC provisioners in developing stockage levels of spare parts. In addition, an analysis of the Marine Corps provisioning model; the Initial Spares Optimization Model (ISOM); Availability Centered Inventory Model (ACIM); and the Multi-Item, Multi-Echelon (MIME) provisioning model is conducted.

Chapter IV describes the methodologies used by the researchers.

Chapter V provides the results of the data analysis.

Chapter VI is a discussion of the researchers opinions, interpretations and comments regarding the analysis.

Chapter VII contains the conclusions and recommendations which are based on the findings contained in Chapters IV, V and VI.

II. BACKGROUND

A. INTRODUCTION

Prior to 1960 the Department of Defense relied heavily on the contractor to provide the government with provisioning data. The lack of an efficient process caused many provisioning problems. From 1960 to the mid 1970's the government published several guidelines in an attempt to standardize provisioning procedures within the Department of Defense. In 1974 the Defense Department published DODI 4140.42, Determination of Initial Requirements for Secondary Item Spare and Repair Parts. This instruction provides the basis for the computation of spare parts requirements [Ref. 10:p. 16].

The current version of DODI 4140.42 along with other DOD published policies provides universal guidance to the military services. In recent years, emphasis has been on decentralizing the process and increasing the responsibility of the different services. While the general framework remains in place, each of the services continue to develop and implement specific but separate provisioning policies. The objectives of this chapter are:

1. To provide a brief overview of the acquisition concepts and practices that affect the provisioning process.
2. To define the Department of Defense's provisioning policy.

3. To outline the Department of the Navy's provisioning policies and practices.

4. To outline the United States Marine Corp's provisioning policies and practices.

The research material summarized in this chapter forms the basis for the study of the Marine Corp's provisioning process.

B. ACQUISITION CONCEPTS AND PROVISIONING PRACTICES

The acquisition of a new weapons systems can be divided into four stages. These phases are the Program Initiation Phase, the Demonstration and Validation Phase, the Full Scale Engineering Development Phase and the Production/Deployment Phase [Ref. 1: p. 2-2]. In aggregate these phases constitute the life cycle of a weapon system. Provisioning decisions made during the life cycle will determine a weapon system's effectiveness and impact its overall cost. Experience has shown that logistic support is a major contributor to life-cycle costs. It is essential that logistic support be considered at the early stages of system/product planning and design [Ref. 4:p. 4].

Logistics in the context of the system life cycle involves planning, analysis and design, testing, production and the sustaining support of a system throughout the consumer use period [Ref. 4: p. 5]. Sustaining support commences with the initial provisioning of spare parts to support a major end item. Initial provisioning is based on maintenance and reliability factors that are developed

through a Logistics Support Analysis (LSA). MIL-STD-1388-1A and MIL-STD-1388-2A deal with the LSA process and LSA documentation requirements respectively. Appendix C and D provide a detailed description of the two documents.

The LSA provides the foundation for the development of Provisioning Technical Documentation (PTD) which is used to forecast secondary item requirements for a new weapon system [Ref. 1: p. 2-1]. Requirement quantities are based on replacement factors developed from contractor engineering estimates, historical data obtained from technologically similar equipment, and data developed by other services. Additionally, provisioning quantities include consideration of:

1. Spares and repair parts covering actual item replacements occurring as a result of corrective and preventive maintenance actions.
2. An additional stock level of spares to compensate for repairable items in the process of undergoing maintenance.
3. An additional stock level of spares and repair parts to compensate for the procurement lead times required for item acquisition.
4. An additional stock level of spares to compensate for the condemnation or scrappage of repairable items [Ref. 4: p.47].

The extent to which these elements influence the provisioning process depends on the outcome of a Level of Repair Analysis (LORA). The purpose of the LORA is to determine the most efficient mix of resources available to support a weapon system. Establishing the level of

maintenance, skill level requirements, and technical documentation will influence the quantity of initial spares bought to support an end item.

As previously mentioned, the DOD provides general guidance pertaining to the provisioning process. It is the responsibility of each military service to develop and implement provisioning policies from which to operate. This has created different provisioning models within the defense establishment. Each of the models accomplishes a similar goal. When a new weapon system is introduced into the inventory, an initial buy of spare parts is procured for support. Figure 2-1 illustrates a simplified version of the provisioning process. It is designed to assist the reader in understanding the Navy and Marine Corps provisioning processes that are presented later in this chapter.

The first step in any provisioning decision is to determine those items that will require logistics support. Recommendations as to the range and depth of spare parts quantities are provided by the contractor. These suggestions are based on reliability estimates, the maintenance concept to be employed and previous system usage data. All are developed from the LSA discussed earlier.

The next step after initiating a production contract is to conduct a provisioning guidance conference. Representatives from the contractor and project office develop an

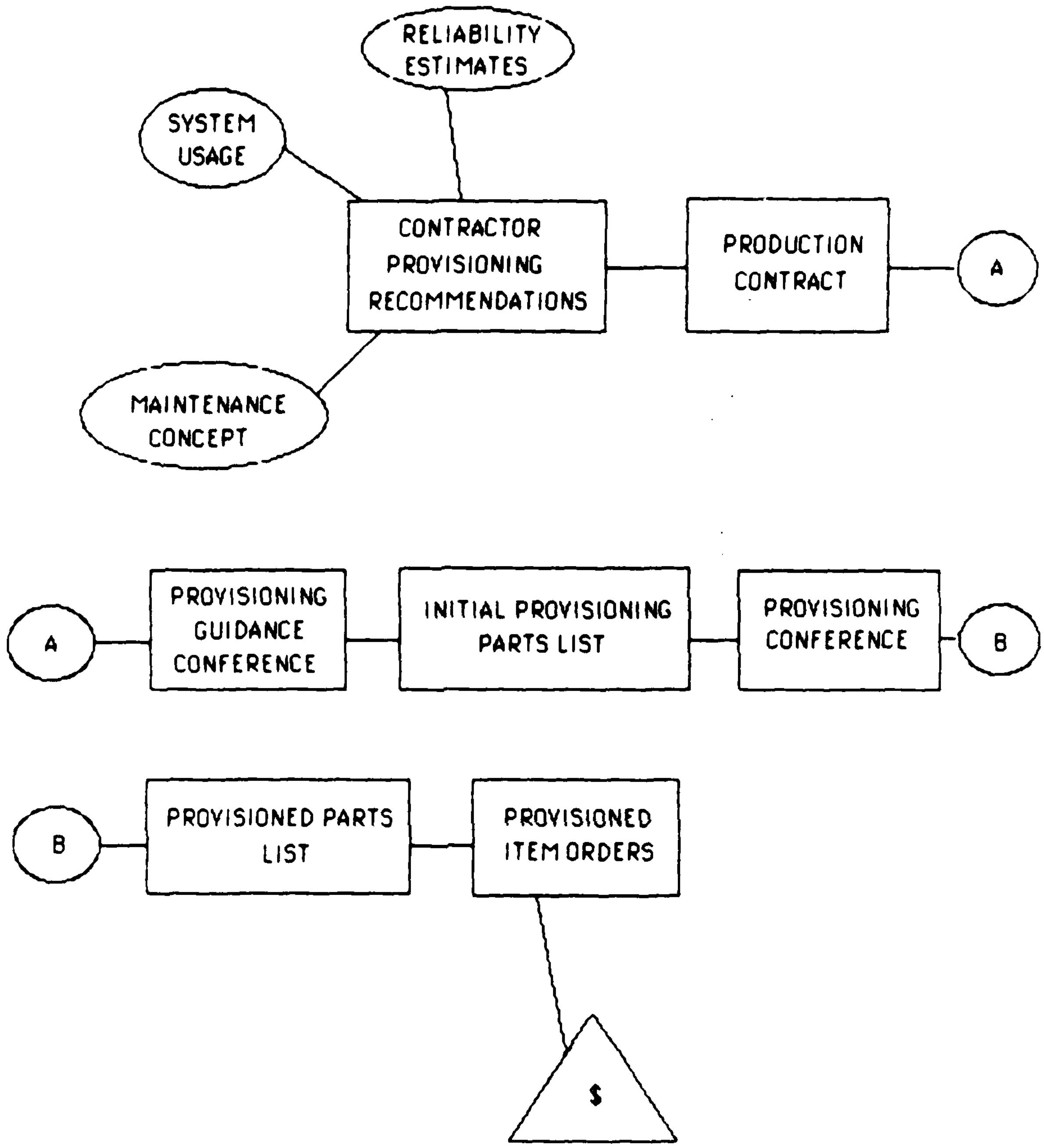


Figure 2-1 Simplified View of the Provisioning Process [Ref 12 p 28]

initial provisioning parts list. From here the list is then scrubbed to identify:

1. Items already supported by the supply system.
2. Items peculiar to the weapon system for which no stock number has been assigned.

Once the initial provisioning list is reviewed a determination is made as to what items and how many to procure. A final list is generated and provisioned items are procured in accordance with the individual services policies.

C. DEPARTMENT OF DEFENSE POLICY AND PROCESS

Spare parts are acquired through two separate processes, initial provisioning and replenishment. During the initial provisioning of a weapon system representatives of the government and private industry make decisions concerning the spare parts required in the initial provisioning package for use during the early fielding of the system. Parts that are available as a result of other weapons systems are provided by the appropriate source of supply. After sufficient usage data is accumulated parts are stocked or replenished in accordance with the appropriate inventory model.

Policy and procedures for determining initial requirements for repair parts are set forth in DODI 4140.42. The intent of this policy is to achieve maximum initial support within available resources and provide peacetime initial

spare parts under a concept that requires supply response times to be kept to a minimum [Ref. 11:p. 2-33]. This policy is achieved by coordinating all elements of the provisioning process. Additionally, DODI 4140.42 requires the services to standardize their approaches to the provisioning process. The intent is to eliminate the possibility of over-procuring initial requirements. The size and scope of provisioning makes this no easy task.

The DOD manages approximately 4 million items each year and processes procurement transactions through 1000 buying offices. It conducts business with over 300,000 separate vendors. The Defense Logistics Agency (DLA) manages 65% of all spare parts in the DOD inventory or 2.5 million items. During FY 84 DLA processed over 30.7 million transactions [Ref. 13: p. 9]. DOD's inventory management mission is to provide material where and when needed to support an organizational mission within fiscal constraints. It is the responsibility of the Integrated Material Manager (IMM) and the appropriate contracting and procurement personnel to ensure that adequate stocks are available in the right quantities and at the correct time to support the multitude of diverse missions within DOD [Ref. 14: p. 7].

The DOD utilizes an inventory model to establish the appropriate level of inventory. The inventory model that is used is based on the principle of cost minimization. Within the services, inventory management is more typically

directed towards maximizing the support of the organization within the financial limitations set by the cognizant authority [Ref. 15:p. 1].

There is no single universal model of successful inventory management due to the wide variety of production requirements and the differences in cost data and requirements between services and industries. A variety of logistics strategies are necessary to accommodate the diverse missions that exist. Holding costs, failure rates, and production leadtimes are important considerations in the determination of stockage levels. An erroneous forecast can lead to the maintenance of an improper level of inventory. This issue will be discussed in detail in Chapter III.

D. NAVY POLICIES AND PROCEDURES

Currently, the Navy uses several alternative DOD approved models to determine initial requirements for a new weapon system. It is not the intent of this section to detail each of the processes. Instead, the following represents a general overview of the Navy's provisioning process.

- Development, promulgation and control of provisioning policy is guided by a Provisioning Policy Group (PPG). The PPG is chaired by Naval Supply (NAVSUP) as lead system command for material management. In addition the PPG has representatives from each System Command (SYSCOM), each Program Support Inventory Control Point (PSICP) and the Fleet Material Support Office (FMSO).

- The Hardware Systems Command (HSC), with assistance from the PSICP, is responsible for end item and modification spares budgeting. This command is also tasked with

planning, programming and budgeting the resources necessary to acquire all levels of initial spare and repair parts.

- Provisioning Technical Documentation (PTD) is acquired by the Hardware Systems Command or PSICP for all end items which will be supported by the supply system. Maximum utilization is made of contractor capabilities to fully develop PTD. Accumulation of data required to produce PTD is specified in Full Scale Development contracts. Delivery of PTD is schéduled to permit timely development of organic support.

- The HSC may designate a Provisioning Engineering Support Activity (PESA) to receive and verify or complete the technical coding of PTD. The HSC is to maintain part level configuration files for the end items under their cognizance. The HSC is responsible for ensuring that the PSICP receives adequate data required to complete the provisioning process.

- The HSC, together with the PESA and PSIP, determines interim and initial spare parts requirements.

- End item contracts contain a Provisioned Item Order (PIO) option to be exercised in a time phase consistent with the delivery of the end items. End item contracts place the same emphasis on spare part deliveries as on the end item deliveries.

- Initial allowance lists issued to consumer activities reflect the requirements to be acquired for initial allowances. Authority for activity drawdown of assets based on major changes to initial allowance lists are not permitted prior to the availability of assets required by the changes.

- HSC's, together with the PSICP, develop plans for transitioning support items into the supply system to ensure a smooth transition to organic Navy support [Ref. 11:p. 2-16].

Though the view presented depicts a well organized process there are a number of distinct activities that must be closely coordinated. The primary inputs include Program Support Data, budgeting and funding of secondary item requirements, Provisioning Technical Documentation,

technical and supply management coding and requirements determination [Ref. 11: p. 2-17].

Program Support Data (PSD) represents the first information provided to the Inventory Control Point (ICP) in the provisioning process. The PSD is required to formulate budget estimates. Since the budget leadtime is in excess of two years, requirements must be estimated prior to the receipt of adequate information for determining the range and depth of the required items [Ref. 11: p. 2-17]. The estimates are made based on the Provisioning Technical Documentation (PTD).

PTD furnishes the necessary technical documentation used to determine the quantity of spare parts necessary to support a weapon system. Navy policy requires that PTD be acquired for all equipment and weapon systems which will be supported by the supply system [Ref. 11: p. 2-21]. MIL-STD-1552A identifies the primary data elements of PTD. These specifications can include provisioning parts lists, technical drawings, item descriptions and other characteristic defining data.

Provisioning Parts Lists (PPL) provide detailed information relating to the item under review. A partial list of the data elements include:

1. Source, Maintenance and Recoverability (SM&R) Codes--used to communicate maintenance and supply instructions. It ensures that a range of spare parts are procured to support a new weapons system [Ref. 11:p. 2-23].

2. Failure Rates which identify the rate at which a a failure occurs during a specified time period [Ref. 4:p. 25].

Next, a simplified overview of the Marine Corps policies and procedures will be discussed.

E. MARINE CORPS POLICIES AND PROCEDURES

The initial provisioning process establishes the range and quantity of initial spare parts required to support an end item from the time the end item is placed into service until full responsibility for support can be assumed by the supply system by routine replenishment.

The Marine Corps is required to rely on the concept development and acquisition efforts of the other services to support its weapon system requirements. For example, spare parts for Marine aircraft are managed by the Navy. The team concept approach is used by the Marine Corps to manage those programs for which the Marine Corps is designated as the lead service [Ref. 16:p. 3-12]. In 1984 the Marine Corps used 300,000 spare parts of which only 22,000 were managed by the Marine Corps. Of the 22,000 only about 6,300 were actually stocked with the remaining 15,700 being procured on an as-required basis [Ref. 17:p. 18].

System acquisition management is exercised by Acquisition Program Sponsors (APS) in Headquarters, Marine Corps (HQMC); the Development Center of the Marine Corps Development and Education Command (MCDEC), Quantico, Virginia; and the Marine Corps Logistics Base (MCLB), Albany, Georgia. In

depth planning and follow-on support is accomplished by Acquisition Sponsor Project Officers (ASPO), Acquisition Project Officers (APO), Development Project Officers (DPO), and Development Coordinators (DC) [Ref. 18].

The APS is a senior staff officer at HQMC who has primary responsibility for ensuring the achievement of an operational capability for a system or task. The ASPO is a member of the APS's staff designated to assist the APS. The APO is responsible for the internal management and coordination of the logistical, technical, and engineering functions within the program. The DPO is responsible for managing, monitoring and coordinating the development effort. His function during the production and operational phase of the acquisition cycle is limited to the operational tests associated with those phases. The DC is responsible for the monitoring of the fiscal aspects of the program and for coordination of correspondence related to the development effort [Ref. 16]. The ASPO, APO, DPO, and the DC form the Acquisition Coordinating Group (ACG). The ACG is an informal committee that meets as required, on request of a member, to facilitate communication, planning, coordination, and to provide guidance as necessary [Ref. 18].

The MCLB, Albany has overall responsibility for all initial issue provisioning and replenishment of spare parts in support of Marine Corps weapon systems and support equipment. It procures spare parts from other IMM's and

from commercial contractors. Together with HQMC, the MCLB, Albany conducts Logistics Support Analysis Record (LSAR) Reviews to identify spare part requirements during full scale development. The LSAR includes 14 individual data records pertaining to some of the technical characteristics of the system [Ref. 4:p. 433]. The LSAR has an automated system, maintained by the Defense Logistics Service Center (DLSC), to screen National Stock Numbers (NSN) to ensure that spare parts are not purchased from the contractor if they are already in the supply system. When spare parts are identified as not in the supply system, the MCLB, Albany submits requests to DLSC to establish the items in the DOD supply system [Ref. 20:p. 1-2]. Initial spare parts can be purchased from a prime contractor in the following circumstances:

- If the items are new and not in the supply system;
- If the procurement leadtimes cannot meet the Initial Operating Capability (IOC) date;
- Overpacking for initial support is required.

The MCLB, Albany is designated as the Primary Inventory Control Activity (PICA) for the Marine Corps and as such is responsible for the actual provisioning and replenishment of spare parts. The Weapons System/Equipment Management Directorate (WS/EM), Technical Support Division and Repair Division manage, coordinate and execute the Marine Corps spare part procurement, repair and stockage programs [Ref. 18]. Initial stockage levels, including garrison operating

stocks, war reserve stocks and system stocks, are developed by MCLB, Albany. To ensure the early identification and optimum procurement of spare parts are realized, the Spares Integrated with Production Program was developed (Appendix E). The underlying concept being that the consolidation of orders to support both production and spares requirements would result in cost savings. MCLB, Albany is tasked with the responsibility of developing and maintaining procedures for collecting, evaluating and storing empirical data used for initial requirements determinations. It is required to establish, maintain and verify the accuracy of the failure factors, order ship time (OST), and resupply rates used for initial allowance computations. The required information is maintained in a provisioning file. The purpose of the provisioning file is for recording initial support, scheduling, publications, NSN's and special tools required to support the end item for the initial period of service [Ref. 20:p. 1-16].

F. SUMMARY

Provisioning is a method used to provide the initial spare parts necessary to field a weapons system prior to the development of sufficient usage data to meet inventory stockage criteria. As such, it represents an important part in the life cycle of a weapon system. The DOD provides general guidance for the provisioning process. It allows the Navy and Marine Corps to select the inventory model that

best meets their needs. There is one primary overriding criterion--the formulas used cannot procure a quantity greater than the DOD model would authorize [Ref.11: p. 2-51].

III. PROVISIONING

A. INTRODUCTION

Chapter III describes the principal approaches available to U.S. Marine Corp's provisioners in determining stockage levels for initial spare parts provisioning. The complexity of this process requires that a systematic approach be taken in the analysis. With that in mind, this chapter will,

1. Briefly describe the acquisition methodologies available to the U.S. Marine Corps.
2. Identify the different provisioning data factors used in provisioning models.
3. Outline the various provisioning categories for initial spare parts procurement.
4. Provide an overview of the Marine Corps provisioning subsystem.
5. Describe the specific models used by the Marine Corps in determining consumable and repairable initial provisioning quantities.
6. Review an analysis or the Marine Corp's provisioning model and three alternatives.
7. Review government contract requirements for data necessary to the provisioning process.

The identification, determination and procurement of quantities of parts sufficient to meet the initial demands for a new weapons system/equipment is an inexact science. The Fleet Marine Forces provisioning experience, since the 1976 publication of the Provisioning Manual, has generated a consensus that the current provisioning policy contributes

to an inordinate spare parts excesses and deficiencies but does not necessarily contribute to high levels of weapons system or equipment availability during introduction [Ref. 21:p. i]. A 1980 Marine Corps staff study concluded that in 65% of the projects studied there was no demand at all for the consumable items provisioned [Ref. 21:p. 4].

To correct this problem requires a close examination of the input variables to the provisioning process. Before analyzing these variables, a basic knowledge of the different acquisition methodologies available to Marine Corps provisioners is necessary.

B. METHODS OF ACQUISITION

The Marine Corps acquires new weapons systems primarily through the acquisition programs of other military services and government agencies. An alternative approach is through joint and unilateral acquisition programs [Ref. 16:p. 2-7]. When determining whether or not to acquire a weapons system through other military services or government agencies, the Marine Corps evaluates the following alternatives:

1. Will the weapon system satisfy the stated requirements.
2. Is the equipment the most cost effective alternative available to meet the need.
3. Can the system meet the initial operational capability date.
4. Will logistic support be available when required.

The process of acquiring a weapon system/equipment from other services begins with a declaration of interest to that service by the Marine Corps. A declaration of interest serves to alert all commands and agencies of the expressed intention of acquiring and deploying the system being developed [Ref. 16:p. 2-8]. Equipment acquisition through other services programs (OSP's) implies that the Marine Corps does not participate in the management of the project. As such, the Marine Corps Research, Development, Test and Evaluation (RDT&E) funding is limited to acquiring items to conduct Initial Operational Testing and Evaluation (IOT&E).

Joint acquisition programs are designed to spread the cost of weapon systems development among the various services and government agencies. The Marine Corps will promote and initiate action to undertake joint acquisition efforts when:

1. The requirement cannot be satisfied through the current or planned acquisition effort of other military services.

2. Unilateral acquisition of a system can be avoided.

3. Considered essential to influence and gain support for a Marine Corps-initiated program either by recommending DOD-approved joint effort or through direct agreement with other military services [Ref. 16:p. 2-10].

With joint acquisition programs the Marine Corps shares and participates in the management and funding for the weapon system and its support equipment.

Marine Corps project officers must understand the acquisition process of the developing services. Marine Corps plans must reflect these processes and milestones in order to influence design, performance characteristics and testing and evaluation of the system [Ref. 16:p. 2-8].

Due to its size and structure the Marine Corps manages only a small number of systems acquisitions. The Marine Corps will only undertake unilateral acquisition efforts when:

1. There is no suitable equipment available or under development by another military service which would meet stated requirements.

2. Development clearly falls within Marine Corps responsibilities established by law.

3. Failure to undertake development action would adversely affect the operational capability of FMF units or forfeit an opportunity for significant improvement in effectiveness, efficiency and economy [Ref. 16:p. 2-10].

No matter which method of acquisition is used, the factors, used to determine initial provisioning quantities, do not change.

C. PROVISIONING DATA FACTORS

Provisioning data is an important input to the requirements determination process. Nothing is more critical to sound decision-making than adequate technical, cost and requirements data [Ref. 22:p. 23]. Initial outfitting quantities are determined by provisioning models designed to maximize logistics effectiveness within a budget

constraint. Provisioning data is used as a measure of logistics effectiveness and can be divided into three general categories; reliability factors, maintainability factors and supply support factors.

Reliability can be defined as the probability that a system or product will perform in a satisfactory manner for a given period of time when used under specified operating conditions [Ref. 4:p. 23]. When determining provisioning requirements, the reliability of the system becomes a significant parameter. Unreliable systems will require an increase in the quantity of initial spares procured. Conversely, a reliable system requires fewer maintenance actions and therefore a smaller initial spares support package.

Quantifying reliability measures for a new weapon system is difficult. The reliability function can be characterized by a number of different probability density functions. These include the binomial, exponential, normal, Poisson, gamma, and Weibull distributions [Ref. 4:p. 25]. In simplest terms, reliability can be considered as a function of the system/equipment failure rate. The Marine Corps considers the failure rate to be the total number of failures within an item population, divided by the total number of life units expended by that population during a particular measurement interval under stated conditions [Ref. 23:p. D-5].

A basic measure of reliability for repairable items is the Mean-Time-Between-Failure (MTBF). MTBF represents the mean number of life units during which all parts of the item perform within their specified limits during a particular measurement interval under stated conditions [Ref. 23:p. D-9]. Simply said MTBF can be thought of as the total system operating time divided by the total number of system failures during that time. Assume that radio XXX operates for 10,000 hours and during that time the radio experiences 100 failures. The MTBF for the radio would be:

$$\text{MTBF} = \frac{\text{10,000 hours}}{\text{100 failures}} \; ; \; \text{MTBF} = \text{100 hours/failure}$$

In this case the failure rate equals 0.01 or 100 failure per 10,000 hours of operating time.

Maintainability is an inherent design characteristic dealing with the ease, accuracy, safety and economy in the performance of maintenance functions [Ref. 4:p. 32]. It is the measure of the ability of an item to be retained in or restored to a specified condition when maintenance is performed by personnel having specified skill levels and using the prescribed level of maintenance and repair [Ref. 23:p. D-8]. Maintainability measures can be grouped into several different categories. Among them are maintenance elapsed times, maintenance frequencies and maintenance costs.

Maintenance elapsed time factors can be separated into two categories:

1. Corrective/unscheduled maintenance, and
2. Preventive/scheduled maintenance.

Corrective maintenance is the replacement or repair of an item that has failed in order to restore that item to specified standards [Ref. 23:p. D-1]. Preventive maintenance on the other hand are the scheduled actions accomplished to retain a system at a specified level of performance by providing systematic inspection, detection, servicing, condition monitoring, and/or replacement to prevent impending failures [Ref. 4:p. 34]. Specific corrective and maintenance goals that a weapon system must meet are specified within the language of the contract. These two factors are normally expressed as an average per unit of time.

To continue with the previous example, assume that the total corrective maintenance time required to repair the 100 failures of radio XXX is 50 hours. Then the mean corrective maintenance time is equal to 0.5 hours. Mean preventive maintenance time of a system is the sum of each preventive maintenance action multiplied by the frequency of that action (fpt) divided by the total number of preventive maintenance actions.

$$Mpt = \frac{\sum (fpt_i)(Mpt_i)}{\sum fpt_i}$$

Two other elapsed time factors include logistics delay time (LDT) and administrative delay time (ADT). Logistics delay time is maintenance downtime expended waiting for logistics support. This support can include waiting for a spare part, transportation, test equipment or use of a maintenance facility. Administrative delay time refers to that portion of downtime during which maintenance is delayed for reasons of an administrative nature [Ref. 4:p. 44]. Both LDT and ADT make up a large portion of total maintenance downtime (MDT). Maintenance downtime is another factor frequently specified in weapon system contracts.

Maintenance frequency factors are closely related to the reliability factors previously discussed. The reliability factors, MTBF and failure rates, are the basis for determining the frequency of corrective maintenance [Ref. 4:p. 45]. Thus, reliability and maintainability are dependent on and supportive of one another. The standard measure for maintenance frequency is the mean-time-between-maintenance (MTBM). It is a measure of reliability taking into account the maintenance policy that has been established for the weapon system. MTBM can be thought of as the total number of life units expended by a given time, divided by the total number of maintenance events (scheduled and unscheduled) due to that item [Ref. 23:p. D-10].

Maintenance costs and other operational support have a major impact on the life cycle cost of a weapon system. An

acquisition management technique that incorporates these cost factors is the concept of design to cost (DTC). DTC's goal is to provide sufficient quantities of a system at an affordable cost. The operational and support parameters are one of several DTC categories. These parameters are values expressed in dollars or by other measurable factors [Ref. 24:p. 5-24]. When considering cost, the following indices may be used:

1. Cost per maintenance action.
2. Maintenance cost per month.
3. Maintenance cost per system operating hour.
4. Maintenance cost per mission or mission segment.
5. The ratio of maintenance cost to total life cycle cost [Ref. 4:p.47].

Supply support factors represent significant inputs to the initial provisioning process. Spare part requirements are initially based on the system maintenance concept, are subsequently defined and justified through the logistic support analysis (LSA) [Ref. 4:p. 47]. Initial provisioning is accomplished using LSA estimates to determine the range and depth of different items in the inventory. These estimates identify the necessary supply support factors of which leadtimes and repair factors are included.

Leadtimes can be divided into three separate categories; Administrative leadtime (ALT), production leadtime (PLT) and procurement leadtime (PCLT). Administrative leadtime is the length of time from the generation of a procurement action

until it is awarded on a contract [Ref. 11:p. A-1]. Production leadtime extends from the procurement contract award until the initial receipt of material from the contract [Ref. 11:p. A-15]. Included within PLT is the delivery leadtime--the time required to ship the item from the manufacturer to the ICP. Procurement leadtimes are the span of time from the generation of a procurement action until the initial receipt from the contract. PCLT is the sum of ALT and PLT.

Another important supply support factor that needs to be considered in developing provisioning quantities is the repair or regeneration factor. This factor estimates the number of units that can be returned to a serviceable condition from repair during a given period of time. When determining provisioning levels both the peacetime and combat repair factors must be considered. These two concepts will be further developed later in this chapter.

As can be seen from the above discussion determining the range and depth of items to be provisioned is a complex task. The objectives in determining spare parts requirements are to identify reliability, maintainability and supply support factors that will achieve a given level of operational availability without wasting valuable resources. Provisioning models are the avenue used to achieve this goal. The specific input factors and models,

used by the Marine Corps to determine provisioning quantities are discussed next.

D. PROVISIONING CATEGORIES FOR INITIAL SPARE PARTS PROCUREMENT

The provisioning process establishes the range and quantity of square parts necessary to support an end item. There are three principle material stockage categories considered in the provisioning process; Initial System Stock, Garrison Operating Level (GOL), and War Reserve Material. Each stockage level is further subdivided into two repair categories of stock; consumable (nonreparable) and reparable. Prior to a discussion of the three material categories an understanding of the difference between consumable and reparable items must be fully understood. A consumable item is, after issue, chemically or physically altered with use to the point that it cannot be reused for its original purpose and is not repaired [Ref. 16:p. A-1]. A reparable item, on the other hand, is an item which can be reconditioned or economically repaired for reuse when it becomes unserviceable. There are three levels of repair (LOR) available for the maintenance of a reparable item. The LOR is determined during the provisioning process and adjusted as required [Ref. 16:p. A-9]. The three levels of repair are described as follows [Ref. 4:p. 109]:

1. **Organizational Repair (Maintenance)**--Organizational repair is performed at the operational site (i.e., at the user level). It includes basic tasks performed by the using organization on its own equipment.

2. **Intermediate Repair (Maintenance)**--Intermediate repair consists of repair by removal and replacement of major modules, assemblies or piece parts. The objective is to provide on-site maintenance (beyond what organizational personnel are trained to accomplish) to expedite the return of the end item to service. Maintenance tasks that cannot be performed at the organizational level are performed here.

3. **Depot Repair (Maintenance)**--The Depot level is the highest level of repair. This level of repair includes the maintenance of items that are beyond the capabilities of the organizational and the intermediate levels. The depot level of maintenance includes the complete overhauling, rebuilding and calibration of equipment as well as the performance of highly complex maintenance tasks.

The primary objective of the provisioning process is to ensure that all spare parts required for Initial System Stock, Garrison Operating Level, and War Reserve Material, for Marine Corps managed requirements, are available and protected prior to the ready for issue (RFI) date [Ref. 20:p. 1-3]. Prior to a discussion of the various provisioning models it is beneficial to have, at the minimum, a layman's understanding of each material category.

- **Initial System Stock** (wholesale and intermediate) includes the range and quantity of Marine Corps managed items, only, required to provide replenishment supply during the usage data development period. Initial system stock levels are computed during the provisioning process as outlined in Appendix F. Consideration is given to the total anticipated demand for the item related to the supported end item, as well as any other related equipment [Ref. 20:p. 1-11].

- **Initial Garrison Operating Level (GOL)** are stocks of spare parts that are prepositioned at the user level within the Fleet Marine Force (FMF). These stocks are located either at the using unit, supporting Material Issue Point (MIP), or the supporting Maintenance Float. For consumable items, the levels of stocks authorized for FMF units are based on the average Order Ship Time (OST) and maintenance replacement rates, however, a

safety level is not included. In the case of reparables, the operational requirements and maintenance capabilities of the FMF organizations are the primary factors in determining the extent of items to be repaired and stockage levels authorized. Stockage levels for support units and Material Issue Points (MIP's) are based on the average OST, maintenance replacement rates, repair rates, repair cycle times and washout rates [Ref. 20:p. 1-8].

- **War Reserve Material Requirements (WRM)** stock consists of material required for the first 60 days of combat, the prepositioned war reserve requirement (PWRMR), and the remainder for the operational war reserve material requirement (OWMR) [Ref. 20:p. 1-9]. The Prepositioned War Reserve Manual, MCO P4400.39, provides specific guidance pertaining to the authorized war reserve level and is beyond the scope of this thesis.

E. MARINE CORPS PROVISIONING SYSTEM

The Marine Corps Logistics Base, Albany is tasked with the responsibility of computing the initial stockage levels of spare parts for using and support units. The actual computations are made by computer utilizing the Provisioning subsystem (subsystem 10) of the Marine Corps Unified Materiel Management System (MUMMS). DOD 4140.22M, the Military Standard Transaction Reporting and Accounting Procedures (MILSTRAP) authorizes the use of Purpose Code G to identify provisioning requirements. Within MUMMS, provisioning is further subdivided into five Purpose Codes (including Purpose Code G) as shown in Figure 3-1 [Ref. 25:pp. 5-15].

The Provisioning subsystem prepares load cards and changes for entry into the Inventory Control Subsystem (subsystem 03). It also furnishes initial issue release

PURPOSE CODE	EXPLANATION
G	Used for initial allowances of new items.
V	Used for initial allowances of established items.
U	Provisioning of War Reserve items.
W	Provisioning of system requirements.
X	Provisioning of system requirements for new items.

NOTE: A purpose code is a code assigned to material within the supply system which provides the reader with a means of identifying the reason for which an inventory balance is reserved [Ref. 16:p. A-8].

Figure 3-1 Provisioning Purpose Codes

cards for release of material to using units and at the same time furnishes requirement changes to transfer material from provisioning to system backup and war reserve. The Provisioning Subsystem provides initial provisioning requirements and prepares support capability reports for the equipment specialist and the provisioner [Ref. 25:p. 1-7]. Manual computations are effected, as required, by provisioners working in conjunction with equipment specialists (item managers) HQMC, and the individual unit (when applicable) [Ref. 26].

F. MARINE CORPS PROVISIONING MODELS

The overall policies to be followed by MCLB Albany, in the computation of stockage levels, is provided in the Provisioning Manual, MCO P4400.79E. The MCLB Albany is

responsible for the computation of initial spare parts for using units and support units of the Fleet Marine Force (FMF). The day levels, of initial operating stock authorized, are considered consumption days based on the number of end items supported. The average OST is based on instock parts (at MCLB) and do not include parts placed on backorder. No consideration is provided for safety stock for initial Garrison Operating Stock [Ref. 20:p. 4-3]. The MCLB Albany utilizes primarily six models in the computation of Initial System Stock, Garrison Operating Level and War Reserve Materiel. One model for consumable and another for reparable items in each material category.

1. Initial System Stock Inventory Model

System stock is required to support the entire quantity of end items in service until routine replenishment can be established. Authorized levels vary depending on the average provisioning program, procurement leadtime, washout rates (resupply rates), whether the item is managed by the Marine Corps or by an Integrated Material Manager (IMM). Only those requirements managed by the Marine Corps will be discussed. Prior to the development of spare part stockage levels the quantity of supported end items and the period in which they will be operational must be known. The Marine Corps uses the Time-Weighted Average Monthly Program (TWAMP) to determine the cumulative monthly buildup of end items during the program time base (PTB). The initial system

stock levels are based on the initial program forecast period (PFP), program time base (to determine degree of management intensity), TWAMP, and the levels authorized as described in Appendix F. Figure 3-2 is an illustration of a PFP which is used in determining TWAMP. Figure 3-3 depicts the development of TWAMP [Ref. 20:p. 4-9]. After the development of TWAMP the stockage levels for consumable and reparable initial system stock are developed in accordance with the formulas that follow. After the requirement is computed the result is rounded down and compared to DODI 4140.42 to determine if procurement/stockage is authorized.

Months	1	2	3	4	5	6	7	8	9	10	11	12
Number of End Items Placed in Service Each Month	2	4	10	20	20	20	20	4	4	4	2	2
Cumulative Program Buildup	1	4	11	26	46	66	86	98	102	106	109	111

<u>Sample Calculation For Month 3</u>

Month 1 + Month 2 + (Month 3 2) = PFP for Month 3

2 + 4 + 10 2 = 11

Figure 3-2 Program Forecast Period

Month	1	2	3	4	5	6	7	8	9	10	11	12
Cumulative Program Buildup	1	+ 4	+11	+26	+46	+66	+86	+98	+102	+106	+109	+111

Total Buildup 766 12 = 64

NOTE: See Figure 3-2 for computation of Cumulative Program Buildup

Figure 3-3 Time-Weighted Average Monthly Program

a. Consumable Parts [Ref. 20:p. 4-10]

$$\text{Requirements} = \frac{A \times B \times C \times [(PLT+3) \times 30 + 90]}{360}$$

where:

A = Peacetime Replacement Factor

B = Quantity required per end item

C = Total end item quantity (based on TWAMP)

PLT = Production Leadtime

3 = Standard Administrative Leadtime (months)

30 = Factor used to convert PLT and administrative leadtime to days

90 = Authorized day level

360 = One year (standard days per year)

b. Reparables [Ref. 20:p. 4-11]:

$$\text{Requirements} = \frac{A \times B \times C \times [(PLT+3) \times 30 + 90] \times (1-RR)}{360}$$

where:

A	=	Peacetime Replacement Factor
B	=	Quantity required per end item
C	=	Total end item quantity (based on TWAMP)
PLT	=	Production Leadtime
3	=	Standard Administrative Leadtime (months)
30	=	Factor used to convert PLT and administrative leadtime to days
90	=	Authorized day level
RR	=	Repair Rate
1-RR	=	Rate that parts are not repaired
360	=	One year (standard days per year)

2. <u>Garrison Operating Level Inventory Model</u>

The initial GOL of spare parts is based on the predicted consumption of the part by the using and support units. As in the case of system stock, the result of the equation is rounded down (fractions are simply dropped). The objective is to arrive at a position in which the initial total quantity of consumable spares will be equal to the quantity required during the average cumulative Order Ship Times (OST's) of the using and support units [Ref. 20:p. 4-4]. Reparable GOL items are maintained at the supporting Maintenance Float. A Maintenance Float is an actual support activity that provides a pool of reparable assets that are available for direct exchange [Ref. 16:p. A-5]. A separate Maintenance Float is established for GOL and

Prepositioned War Reserve (PWR) stock [Ref. 20:p. 4-5]. The equations that follow are utilized to compute GOL.

a. Consumables [Ref. 20:p. 4-4]:

$$\text{Requirement} = A \times B \times C \times \frac{OST}{360}$$

where:

A = Peacetime Maintenance Replacement Rate (MRR) per item per year

B = Quantity required per end item

C = Number of end items authorized (based on Table of Authorized Material (TAM)/Table of Equipment (T/E)

$\frac{OST}{360}$ = Cumulative average OST

b. Reparable Garrison Operating Level Inventory Model [Ref. 20:p. 4-5]

The criteria for the development of reparable inventory levels are based on the Maintenance Float Replacement Rate (MFRR), Repair Rate (RR), Resupply Rate (RSR), and the Repair Cycle Time (RCT). Each factor will be discussed, briefly, in order to provide a better understanding of the model [Ref. 20:pp. 4-5--4-6].

(1) **The Maintenance Float Replacement Rate (MFRR)** is the total number of times each month that an unserviceable part is replaced (with a serviceable one) for all end items. The reason that the part became unserviceable is not considered. The MFRR is computed based on the following formula:

$$\text{MFRR} = \frac{A \times B \times C}{12}$$

(2) **The Repair Rate (RR)** is that rate for which unserviceable parts are returned to serviceable condition. It is determined based on data provided in the Logistics Support Analysis (LSA) or other data provided by the contractor.

(3) The rate at which parts are anticipated to require replacement is the Resupply Rate (RSR). This is generally computed by the formula:

$$RSR = 1 - RR$$

(4) The time (in days) it takes to restore an unserviceable part to serviceable condition is defined to be the Repair Cycle Time (RCT).

The equation for reparable GOL can now be presented:

$$\text{Requirement} = (RR \times MFRR) \times \frac{RCT}{30} + (RSR \times MFRR) \times \frac{OST}{30}$$

where:

A = Peacetime Maintenance Replacement Rate per item per year

B = Number of times the repair part is used in one end item

C = Number of end items authorized (based on the Table of Authorized Material (TAM)/Table of Equipment (T/E)

RR = Repair Rate

MFRR = Maintenance Float Replacement Rate

RST = Resupply Rate

RCT = Repair Cycle Time

OST = Order Ship Time

3. War Reserve Requirement Material Inventory Model

The WRM is a level of stock required to be maintained in the event of a combat environment. The WRM consists of Prepositioned War Reserve Materiel Requirements (PWRMR) and Other War Reserve Materiel Requirements (OWRMR). OWRMR is centrally managed by the Marine Corps Stores System for use as resupply. The resupply level for each Marine Amphibious Force (MAF) is based on the difference between PWRMR and the total WRM. The WRM is computed, for each MAF, as follows.

a. Consumable War Reserve Materiel [Ref. 20:p. 4-7]:

$$\text{WRM} = A1 \times B \times C \times \frac{\text{Support Period (days)}}{360}$$

where:

A1 = Combat Maintenance Replacement Rate (MRR)

B = Number of times the part is used in one end item

C = Number of end items authorized (based on the TAM/TE)

PWRMR is that segment of the total WRM that is colocated with the using unit that is expected to be involved in a combat situation, the Marine Amphibious Force (MAF). It's (PWRMR) purpose is to insure that the MAF has sufficient parts to support itself until resupply can occur. To determine PWRMR the following formula is used (based on a 60 day supply):

$$PWRMR = A1 \times B \times C \times \frac{60}{360}$$

If, as a result of the preceding formula, no stock is authorized for a critical item the Marine Corps requires the use of a revised formula.

$$PWRMR = A1 \times B \times C \times \frac{360}{360}$$

Once the total WRM and PWRMR has been developed OWRMR is easily computed. The equation for computing resupply is:

$$OWRMR = WRM - PWRMR$$

b. Reparable War Reserve Materiel [Ref. 20:p. 4-8]:

$$WRM = \frac{(RR \times MFRR1) \times (RCT + RSD)}{30}$$

$$+ \quad (RSR \times MFRR1) \times \frac{\text{Support Period (days)}}{30}$$

where:

RR = Repair Rate

MFRR1 = Monthly Combat Replacement Rate

RCT = Repair Cycle Time

RSD = Repair Start Date which is the day that the intermediate maintenance activity is fully operational

RSR = Resupply Rate.

As in the case for consumables PWRMR is computed separately and is a portion of the total:

$$PWRMR = \frac{MFRR1 \times (RCT + RSD)}{30}$$

If the above equation fails to yield a quantity of at least one, for a critical item, then the following formula is utilized:

$$PWRMR = \frac{MFRR1 \times 360}{30}$$

OWRMR is again nothing more than the remainder of WRM after PWRMR is computed, mathematically:

$$OWRMR = WRM - PWRMR$$

G. COMPARISONS OF INITIAL PROVISIONING MODELS

Competition for resources with other services, increasing equipment complexity, and higher costs have forced the Marine Corps to review its provisioning processes. Current Marine Corps procedures use simple manual formulas to compute stockage levels. These formulas

rely on historical data and contractor supplied information for determining spare part quantities.

Provisioning models are designed to provide the necessary spare parts required to meet initial demands while at the same time minimizing the cost to support a weapon system. Currently, the Marine Corps spares to meet goals for individual item availability instead of the more common practice of sparing to meet weapon system availability goals [Ref. 28:p. 1].

The purpose here is to evaluate the effectiveness of current Marine Corps models with the proposed ISOM model. Additionally, the ISOM will be evaluated against Navy provisioning models to determine if a more effective provisioning methodology is available.

The initial spares operating model is a computer-based model that calculates initial provisioning of spare parts for new equipment based on end item availability. ISOM is designed to determine requirements for garrison and war reserve spares. The Marine Corps comparison of the ISOM model with provisioning practices prescribed in MCO P4400.79E requires establishing a common performance measurement.

In October of 1986 the MCLB Albany published their results of the ISOM performance test. Weapon system availability was chosen as the performance measure for each of the models. This test utilized three weapon

system/equipment provisioning projects. Of these three, two are the M224 LWC mortar and the AN/VRC-83 (V)2 radio set which will be discussed in Chapters V and VI.

The results indicate that in all cases the ISOM model provides greater operational availability within the budget constraints established. Figure 3-4 indicates higher levels of combat and peacetime operational availability for the LWC mortar when using the ISOM model.

Test results for the radio provisioning project indicate substantial differences in combat and peacetime Ao, cost, and average contribution to Ao between MCO P4400.79E and the ISOM [Ref. 29:p. 3]. Figure 3-5 clearly displays the superiority of the ISOM model. This is due to the nature of the model; maximizing system availability, vice individual item availability.

Figure 3-6 reveals that under present procedures, cost computations for stockage levels are considerably greater than ISOM. An apparently inordinate amount of system stock is computed by MCO P4400.79E confirming that there are program errors in these computations [Ref. 29:p. 3]. Figure 3-6 also indicates that the stockage level cost computed by the ISOM approximates the actual provisioning financial plan (PFP) budget utilized for the AN/VRC-83 (V)2 program.

ISOM represents a dramatic improvement over the Marine Corp's current initial provisioning policy. However, there is still room for improvement. One of the options available

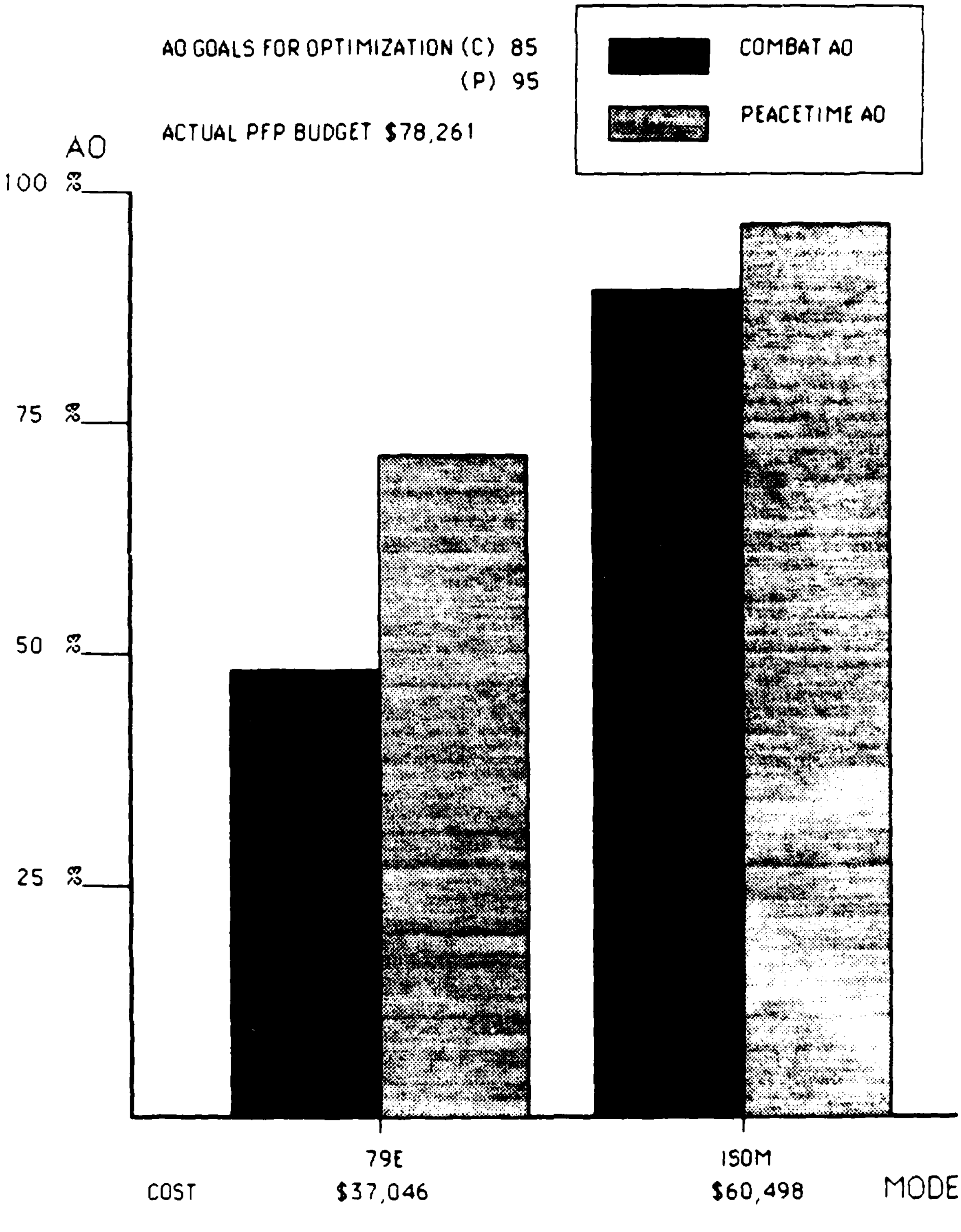


Figure 3-4 ISOM Performance Test LWC Mortar, 60 MM

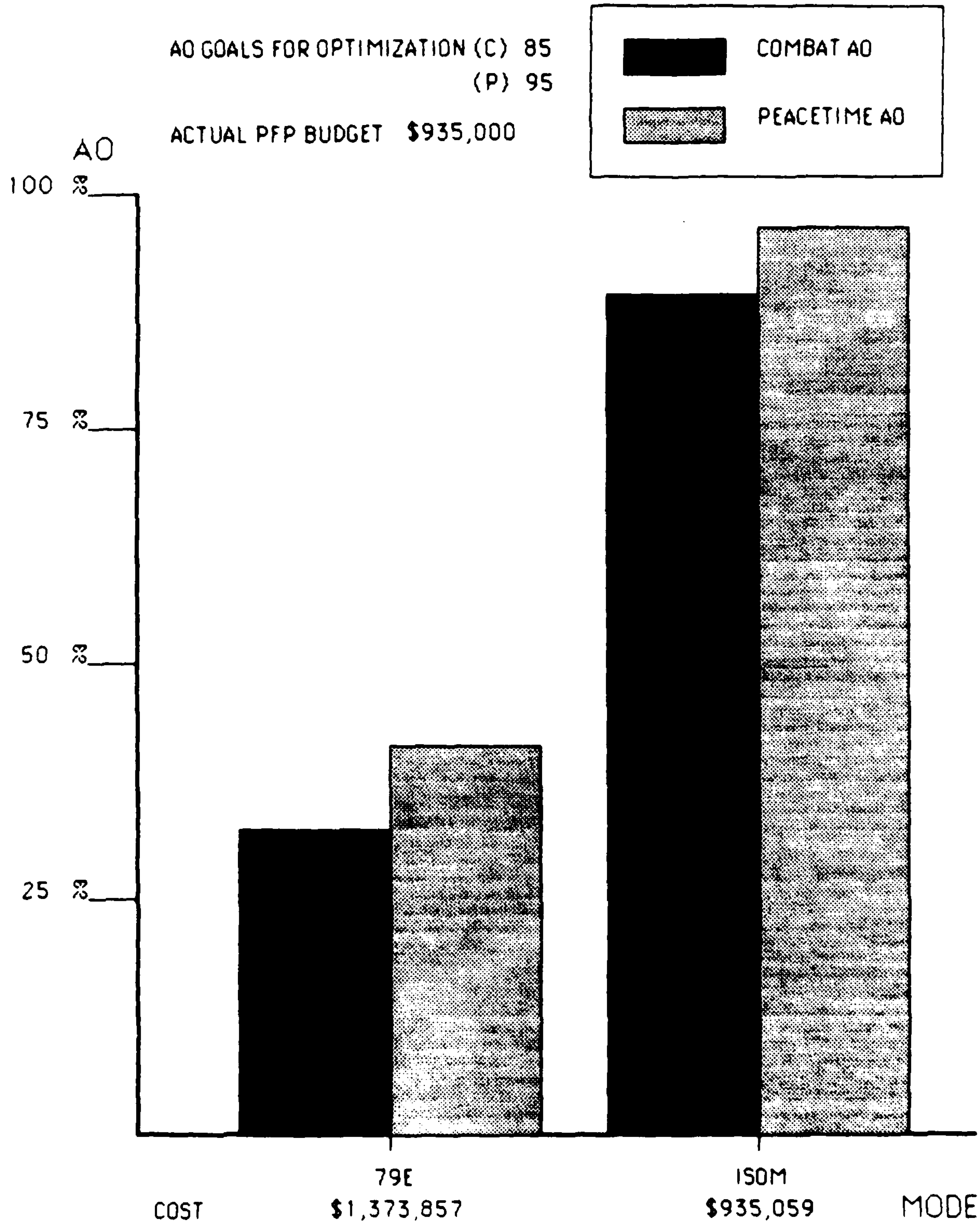


Figure 3-5 ISOM Performance Test AN/VRC-83(V)2

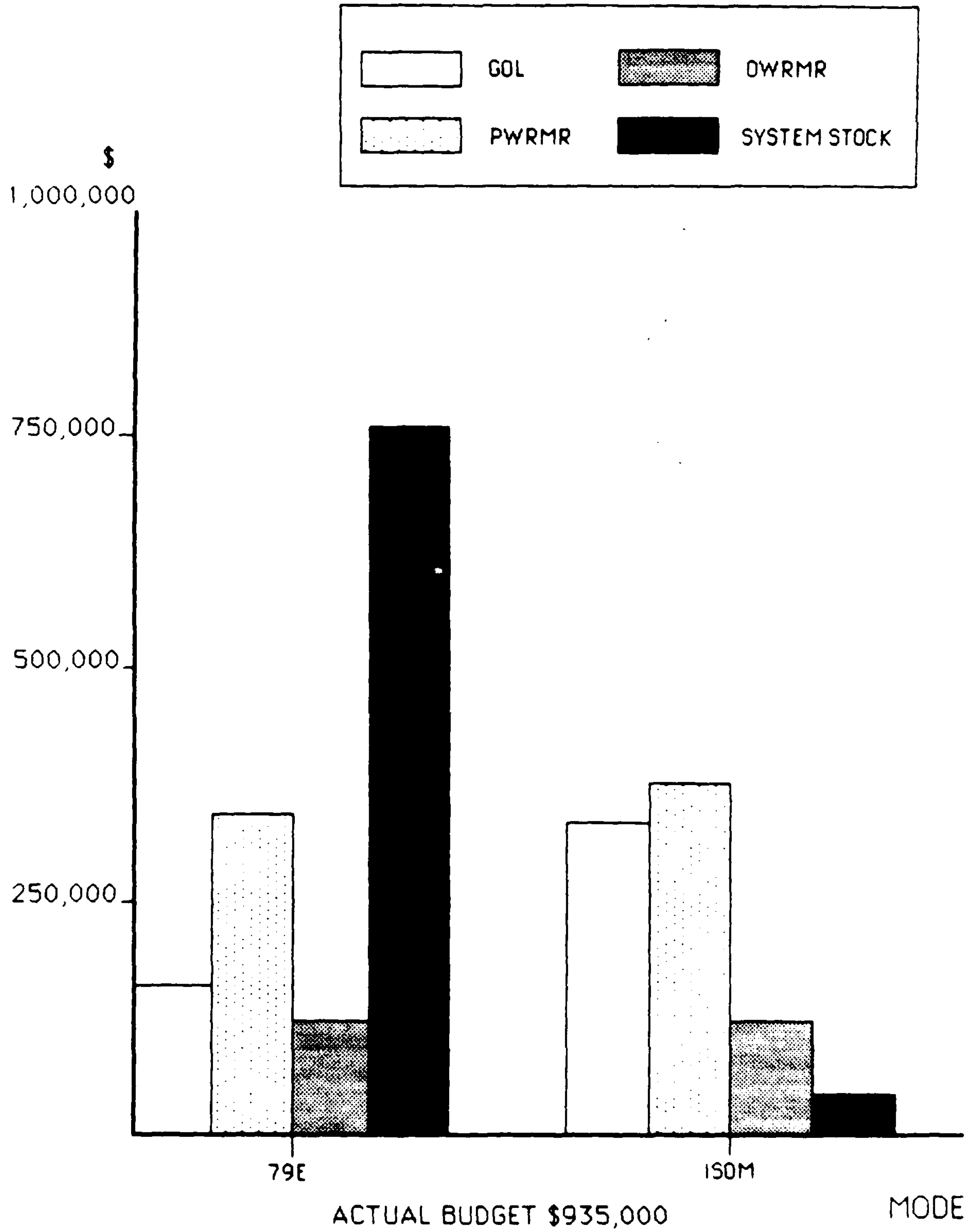


Figure 3-6 ISOM Performance Test AN/VRC-83(V)2

is to replace ISOM in favor of a different spare parts optimization model.

The U.S. Navy currently uses a variety of provisioning models in developing initial spare parts levels. The purpose here is not to detail each of these models. Instead, we will focus on two particular models.

The Navy's availability-centered inventory model (ACIM) is used to compute allowances for ship weapon systems when it is shown that the system's readiness objective cannot be achieved using standard provisioning models. The ACIM determines stockage amounts such that a given level of equipment operational availability is achieved at least cost in terms of inventory investment [Ref. 11:p. 2-D-1].

The multi-item, multi-echelon (MIME) provisioning model, developed by the Center for Naval Analyses, is used to examine sparing models for the Navy's aviation consolidated allowance lists (AVCALs). Echelons refer to locations where spare parts are stored and where maintenance is performed. There are three such echelons in the Navy; organizational, intermediate and depot. Multi-echelon models provide spares for different echelons jointly. These echelons may be located at one base or at different geographical sites [Ref. 28:p. iv].

Computer sparing models feature a number of elements that can be used as a basis for comparison. When evaluating

ISOM, ACIM and MIME it is important to include the following factors:

1. The objectives that each model is designed to reach.
2. Constraints that each model is subject to.
3. Input variables used in each model.
4. Output that is generated by each model.

How these four elements affect ISOM, ACIM and MIME is important in performing an evaluation of the three models.

The two most common objectives found in provisioning models are the maximization of availability constrained by a budget and minimization of a spare parts budget subject to an availability target [Ref. 28:p. 6]. ISOM measures availability two different ways; combat and peacetime. Additionally, the ISOM model computes provisioning levels from two different budgets. In contrast, both the ACIM and the MIME provisioning model use one set of availability standards and a single budget to compute initial spare part levels.

Constraints specify the relationship among different input variables and limit the use of resources to the amount available. Constraints common to the three models being studied include the funds available to procure initial spares and the degree of operational availability required to be achieved. One of the primary constraints on any spare parts model is the operation of the supply system [Ref.

28:p. 6]. These constraints include order and shipment times, manufacturer leadtimes and administrative delay time.

Input data consist of information provided by the user or manufacturer. This data describes the operating characteristics of the equipment/component and is used to develop initial spare part quantities. Most of the provisioning models have similar data requirements. The three models reviewed all use data obtained from engineering test results, the level-of-repair analysis and the logistics support analysis [Ref. 28:p. 11].

Output that results from the various models represents useful management information to the provisioner. The quantities of initial spares are designed to meet availability goals for a given budget constraint. These quantitative factors represent the first cut at determining initial inventory levels. They must be incorporated with qualitative information to determine final stocking levels. However, the purpose here is to focus on the quantitative outputs produced by the ISOM, ACIM and MIME models.

In the spring of 1986 the Center for Naval Analyses (CNA) published an evaluation of the Marine Corps spare parts policy and the initial spares optimization model. An important aspect of the CNA's report includes the comparison of the ISOM model to the Navy's ACIM and MIME provisioning models. Two weapon systems are used to evaluate the ISOM model. One is the Marine Corps night-vision goggle program.

This project consists of a relatively small and inexpensive parts list [Ref. 28:p. iv]. The other is the Navy's F-14 aircraft, which requires a large and expensive parts inventory [Ref. 28:p. v].

Availability achieved given a specified budget level is used to measure the performance between the three models. The question to be answered thus becomes, "Are the models significantly different in their availabilities and costs?" A positive response identifies a superior model.

Table 3-1 identifies the system parameters used in calculating the initial spare parts for night vision goggles. Because this is a Marine Corps project the variables are specified for the ISOM model and then translated into the ACIM and MIME models.

Table 3-2 displays the results of CNA's analysis. The peacetime availabilities achieved by each of the three models varies with different spare parts budgets. ACIM and MIME provide better equipment availability with a budget of $1,000 or less. However, with budgets greater than $1,000 the ISOM model achieves a greater equipment availability.

The next step in the CNA study compares the availability of night vision goggles with MCO P4400.79E and the ISOM model. No direct comparison can be made with MIME and ACIM since the manual system stocks to neither a fixed availability nor a budget constraint [Ref. 28:p. 21].

TABLE 3-1

SYSTEM PARAMETERS USED IN CALCULATING SPARE PARTS FOR NIGHT-VISION GOGGLES [Ref. 28:p. 19]

Combat availability	.85
Peacetime availability	Varies
Probability against stockout, resupply	.85
Support period, PWR	60 days
Support period, other war reserves	60 days
Order-and-shipment time	90 days
Procurement safety levels	90 days
Local delay times	.01 day
Number of end items	500
Optimization of GOL	Yes
Optimization of war reserves	No
System stock	0
Critical low-density item	No
Budget	Varies

TABLE 3-2

PEACETIME AVAILABILITIES OF NIGHT-VISION GOGGLES OBTAINED WITH CONSTRAINED INITIAL BUDGET [Ref. 28:p. 19]

Budget for initial spares	Equipment availability ACIM	MIME	ISOM
$ 5	.8528	.8528	.8508
$ 100	.8748	.8749	.8680
$ 500	.8874	.8874	.8829
$ 1,000	.8979	.8979	.8885
$ 5,000	.9315	.9180	.9339
$ 10,000	.9539	.9193	.9339
$ 50,000	.9540	.9230	.9545

Table 3-3 indicates that with a fixed budget of $174,895 the ISOM model provides significantly greater equipment availability. In fact, ISOM can achieve the same availability as the manual system for one quarter the cost.

TABLE 3-3

AVAILABILITY OF NIGHT-VISION GOGGLES WITH MCO P4400.79E AND ISOM [Ref. 29:p. 22]

Provisioning Method	Equipment Availability Combat	Peacetime
ISOM	.9999	.9990
Manual system	.9720	.9160

The final analysis uses the Navy's F-14 aviation consolidated allowance list (AVCAL) to compare different combinations of equipment availability and spare parts costs. For the F-14 AVCAL, ISOM is compared only with MIME [Ref. 28:p. 35]. Table 3-4 presents the parameters used in the CNA model comparisons. Table 3-5 displays the peacetime availabilities obtained at various funding levels. The MIME model outperforms ISOM at all levels with the exception of the $75 million budget.

The CNA study concludes that the ISOM model significantly outperforms the Marine Corp's manual system. While the input data is similar for each model, ISOM provides greater availability at a lower cost. Additionally, the CNA concludes that the ISOM model compares favorably to the

TABLE 3-4

SYSTEM PARAMETERS USED IN MODEL COMPARISONS:
F-14 AVCAL [Ref. 28:p. 37]

Combat availability	.77
Peacetime availability	Varies
Probability against stockout, resupply	.85
Support period, PWR	60 days
Support period, other war reserves	60 days
Order-and-shipment time	90 days
Procurement safety levels	90 days
Local delay times	.125
Number of end items	24
Optimization of GOL	Yes
Optimization of war reserves	No
System stock	0
Critical low-density item	No
Budget	Varies

TABLE 3-5

PEACETIME AVAILABILITIES OBTAINED WITH CONSTRAINED
BUDGETS: F-14 AVCAL [Ref. 28:p. 37]

Budget (in millions)	Peacetime Availability MIME	ISOM
$ .75	.04	.03
$ 5	.07	.06
$ 10	.11	.09
$ 25	.24	.20
$ 50	.49	.46
$ 75	.78	.78

Navy's ACIM and MIME provisioning models. The optimization routine of ISOM provides spare-parts inventories similar to those obtained by other military spare parts models [Ref. 28:p. 44]. Finally, the report points out that to meet the Marine Corp's need to compute garrison and PWR requirements other provisioning models will have to be modified.

H. CONTRACTOR REQUIREMENTS

Up to this point Chapter III has identified the provisioning data factors and provisioning models used to determine initial spare parts quantities. Contracts play an important role in ensuring that sufficient provisioning data is supplied to the provisioning process. A general knowledge of contractor supplied information is necessary.

The submission of PTD is not an automatic action on the part of manufacturers. Marine Corps contracts identify to manufacturers the extent of their obligation to provide necessary technical data. Data requirements expressed as data item descriptions (DIDs) identify specific data requirements on the DD Form 1664 to provide both the user and the contractor with a clear description of the content, intent and purpose of the data [Ref. 16:p. 3-14]. The DD Form 1664 defines the format that technical documentation should be prepared in. Contract requirements for reliability, maintainability and supply support provisioning factors are identified through the use of various military

standards. Table 3-6 identifies the commonly used standards cited in Marine Corps contracts.

TABLE 3-6

COMMONLY USED MILITARY STANDARDS

STANDARD	DESCRIPTION
MIL-STD-470A	Maintainability Program for Systems and Equipment
MIL-STD-721C	Definition of Terms for Reliability and Maintainability
MIL-STD-785B	Reliability Programs for Systems and equipment development and production
MIL-STD-1388-1A	Logistics Support Analysis
MIL-STD-1388-2A	Logistics Support Analysis Record
MIL-STD-217D	Reliability Prediction for Electronic Equipment
MIL-HDBK-472	Maintainability Predictions
MIL-STD-471A	Maintainability Verification, Demonstration and Evaluation
MIL-STD-756B	Reliability Modeling and Prediction
MIL-STD-881A	Work Breakdown Structures for Defense Material Items
MIL-STD-1561	Uniform DOD Provisioning Procedures
MIL-STD-1562	Uniform DOD Requirements for Provisioning Technical Documentation

These standards define the provisioning technical documentation that the contractor and subcontractors must supply. They identify the methods available and limits

placed on the contractor when developing reliability, maintainability and supply support factors.

IV. METHODOLOGY

A. INTRODUCTION

This chapter is concerned with the methods used for collecting the research data and the structure of the analysis. In so doing, we will focus on four major areas. They are:

1. A description of the sample being measured.
2. A definition of the variables used to measure the sample.
3. A review of how the variables are constructed and measured.
4. A description of the data analysis to be performed.

When performing any data analysis, it is important for the researcher to isolate the variables to be studied. In the case of provisioning, the Marine Corps calls these variables, factors. While these two words possess distinctly different meanings, they can be considered synonymous and are therefore used interchangeably throughout this chapter.

B. SAMPLE DESCRIPTION

The Marine Corps uses approximately sixteen separate factors to determine stockage levels for its various categories of supply. These data are stored in the provisioning subsystem of the Marine Corps Unified Materiel Management System. The provisioning subsystem provides

initial provisioning requirements and prepares support capability reports for the provisioner [Ref. 25:p. 1-7].

At the time of our research the Marine Corps logistics base was in the process of converting their provisioning files to a database computer system. In addition, historical data are not maintained in all cases. As a result, the research was limited to analyzing those factors for which data were available.

Working in conjunction with the Office of the Deputy Commander for Logistics, MCLB Albany, two of the sixteen provisioning factors were selected for analysis. Production leadtimes (PLT) and peacetime replacement factors represent two of the more critical factors in the provisioning process.

The Marine Corps provisioning file served as the primary data file for the compilation of empirical information for this thesis. Raw data used during the conduct of this thesis can be obtained utilizing a locally generated computer program to inquire the logistics database at MCLB Albany.

A comparison of PLT based on contractor and provisioners estimates to the actual data (after actual data became available) was conducted to verify if forecasted data reflected actual performance data.

A class III program was developed to assist in our analysis of peacetime replacement factors. The provisioning

file was queried for all stock numbers, grouped by Federal Supply Class, and manufacturer.

C. VARIABLE DEFINITION

1. Production Leadtime

The forecasting of production leadtimes is instrumental in establishing when an order will be placed and for what quantity. Production leadtime is the time from receipt of the order by the supplier to receipt of the item into the inventory [Ref. 4: p. 57].

Provisioners at the ICP generally review production leadtime data provided by the contractors and adjust it according to their best professional estimate, which is based on past experience. Data resident in the provisioning file, then, is questionable as to whether it is actually the contractors data or data adjusted by one of many provisioners. Interviews held at the ICP indicated that once the data is manually input into the system, there is no practical method of recapturing the original contractor information.

2. Peacetime Replacement Factor

The peacetime replacement factor (similar to the maintenance replacement rate) is defined as the total number of times per month, for all end items in use, that an unserviceable item is expected to be replaced with a serviceable item during peacetime [Ref. 20: p. 4-5]. The

cause of the failure is not considered; the requirement for replacement of the item is the only relevant factor.

Replacement factors (frequency of replacement) are developed by the contractor based on inherent reliability estimates. The factor (data) is provided to the provisioner for inclusion into the provisioning file.

Overall system operational availability is heavily influenced by replacement factors. If the manufacturer provides a replacement factor that is too low, the stockage level will be less than actually required. The provisioning of too little support increases the probability of a stockout, which is costly. Conversely, if the manufacturer provides too high a replacement factor, then excess inventory will be maintained. This too is costly in terms of inventory holding costs.

D. VARIABLE CONSTRUCTION AND MEASUREMENT

Simply stated, production leadtime is the time, measured in days, it takes a supplier to manufacturer a piece of equipment. The process, unfortunately, is far more complicated than it sounds. In fact, PLT is a function of a number of various elements. A few of the more important are:

1. The supplier's manufacturing processes.
2. The technical complexity of the part being manufactured.

3. The availability of raw materials.

4. The manufacturer's production learning curve.

The contractor's manufacturing processes are important in determining the production leadtime for a piece of equipment. The greatest impact in this area is the supplier's ability to produce the part. The question that must be addressed when developing a PLT estimate is:

> Does the contractor possess the manufacturing process? If not, can the process be developed in a reasonable amount of time?

The answer will determine the production leadtime for manufacturing the part. If the supplier has the capability to produce the item then the PLT will be short. On the other hand, if a manufacturer has to develop the processes then the PLT will be long. These two examples represent the extremes on the spectrum. A more likely event is that the manufacturer possesses the capability but will require a period of time to re-tool before beginning production.

Another influencing element of PLT is the technical complexity of the part being manufactured. This also has an impact on a contractor's manufacturing processes. Parts using "state of the art" technology possess a relatively short PLT compared to parts with new, unproven technology. In the latter case, much more testing and quality assurance must be performed.

The next area to affect production leadtime is the availability of raw materials. Parts that require the use

of scarce materials can require greater production leadtimes. Additionally, if the contractor does not maintain the materials, then they will have to be obtained before production can begin.

The final area to be reviewed concerns the contractor's production learning curve. Manufacturers with experience in producing a particular part can produce in a shorter period of time at a cheaper cost. This is due to more efficient assembly methods and tools, and improved management techniques.

Each of these elements are measured in days. When summed, they equal the production leadtime to produce a particular part. The production leadtime factor can be set three different ways; by the contractor, the provisioner, or by the default parameter p aced in the provisioning files.

Peacetime replacement factors are a little more difficult to develop and understand than production leadtimes. The most important thing to remember is that estimating peacetime replacement factors is an inexact science. For the most part, peacetime replacement factors are developed from:

1. Past historical data.
2. Contractor supplied information.

Past historical data can be used to develop replacement factors when the item being developed is similar to a previously provisioned item. The similarity between the old

and new item must include the technology used to develop, materials used in manufacturing and the operational requirements expected of the parts.

The advancing development of weapon system technology causes historical data to become outdated at a faster rate than ever before. Using historical replacement factors to develop provisioning quantities can create excess inventory levels or part shortages which lead to loss of weapon system availability.

While not 100% accurate, contractor supplied replacement factors provide a much better measure than historical data. Contractor replacement factors are determined through a failure analysis of the part(s) being provisioned. This analysis is a logical systematic examination of an item, its construction, application, and documentation to identify the failure mode and determine the failure mechanism and its basic cause [Ref. 23:p. D-4].

The failure rate of an item is determined by the number of failures of an item divided by the total number of hours the item is in use (operating cycle). The replacement factor is directly related to the failure rate of an item. Each time a part fails, it must be replaced. Therefore, an item's peacetime replacement factor is determined by the number of times the item is replaced during the operating cycle.

It is important to remember that peacetime replacement factors are engineering estimates. As such, they are subject to some amount of variability. The closer these estimates are to actual replacement figures will determine the degree of success in developing provisioning quantities.

E. DATA ANALYSIS DESCRIPTION

In structuring our data analysis, one hundred and twenty eight separate Federal Supply Classes (FSC) were considered. The material ranged from weapons components, aircraft structural components, engines, valves, radar equipment to computer devices. This equipment covered the full range of material supported by the ICP.

Three provisioning projects were chosen for our analysis of production leadtime; the light weight company mortar (M224), AN/VRC-83(V)2 radio set and the AN/PRC-68 radio set. These three projects consist of 263 separate line items or components ranging over 48 different Federal Supply Classes. The provisioning file was queried for each project to provide the original estimate of PLT and the PLT based on actual data captured since the release of the project.

Initial peacetime replacement factors used by the ICP to estimate inventory requirements are based on a combination of reliability theory and a failure mode analysis or historical data for similar items compiled by the equipment manufacturer (Ref. 11:p. 2-J-1).

In order to compare various manufacturer's replacement factors it was necessary to develop a rough standard from which each manufacturer could by evaluated. Towards this end, all stock numbers were grouped within their respective Federal Supply Class. Figure 4-1 illustrates the relationship between FSC, stock number and peacetime replacement factor. The failure factor for each stock number in a class were summed and divided by the total number of stock numbers within the particular class. The result for each FSC became the industry standard or base. The following equation aids in conceptualizing the process.

$$\text{Industry standard} = \frac{\sum_{N=1}^{i} \text{Stock numbers}}{N}$$

where N is equal to the total number of stock numbers in the class.

Next, the replacement factor provided by the manufacturer for a Federal Supply Class was summed for each manufacturer to develop the manufacturer's average Peacetime Replacement Factor. This technique permitted comparison between an individual manufacturer's average replacement factor for a particular FSC and the industry average.

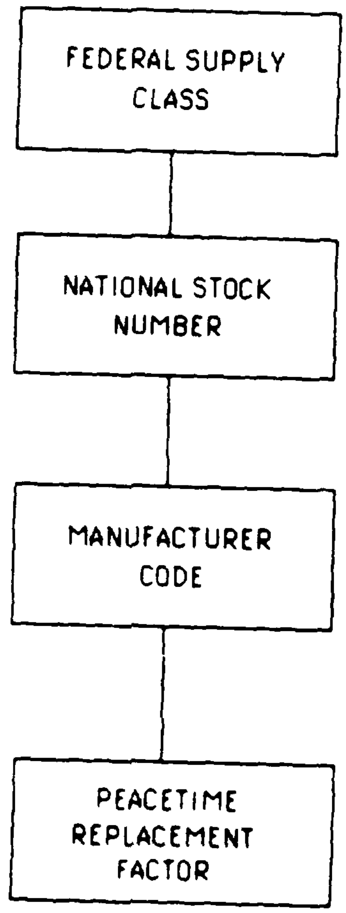


Figure 4-1 Hierarchical Relationship between FSC, NSN and Peacetime Replacement Factor

V. RESULTS

A. INTRODUCTION

The purpose of this chapter is to present and discuss the results of two critical factors that affect the provisioning process. The methodology for extracting, from the provisioning file, and compiling the data was discussed in Chapter IV. First, Production Leadtime (PLT) will be evaluated by comparing the estimated production leadtime to the actual production leadtime in three recent U.S. Marine Corps provisioning projects. These projects are:

1. M224 Lightweight Company Mortar (LWC)
2. AN/VRC-83 (V)2 radio set
3. AN/PRC-68 radio set.

Next, the Peacetime Replacement Rate for which data are maintained in the provisioning file will be presented. A comparison of the actual replacement rate to an industry standard will be discussed.

B. PRODUCTION LEADTIME

Two hundred and sixty three separate NSN's representing thirty three FSC's were considered. The materials ranged from weapons components to electronic devices and circuitry. Thirteen prime contractors were used to manufacture the projects.

Of the two hundred and sixty three NSN's, two hundred and forty nine were delivered early. The analysis of data, in Table 5-1, reveals that the average estimated PLT is significantly greater than the mean actual leadtime observed in the data.

TABLE 5-1

COMPARISON OF ACTUAL PLT TO ESTIMATED PLT

Average Actual PLT (in days)	Estimated PLT (in days)	Difference
148.03	444.7	296.67

The estimated PLT exceeded the actual PLT 94.7% of the time. There were one hundred and nineteen NSN's that exceeded the actual performance data by three months or 45.25% of the total data population. In only ten cases (3.8%) were estimates below actual PLT data. The results of the analysis for each project are displayed in Table 5-2.

TABLE 5-2

PRODUCTION LEADTIME ANALYSIS

PROJECT	NUMBER ESTIMATES ABOVE ACTUAL PLT	NUMBER BELOW ACTUAL PLT	NUMBER EQUAL TO ACTUAL PLT
LWC	117	4	3
AN 83	108	0	0
PRC 68	24	6	1

Clearly, there is a tendency for early shipment of material or over-statement of the estimated PLT by the contractor. Figure 5-1 graphically displays the results of the analysis. The following is a brief description of the results of the analysis for each project.

1. M224 Lightweight Company Mortar (LWC)

The LWC consisted of one hundred and twenty four NSN's. One hundred and seventeen NSN's exceeded actual PLT or 94.35% of the total for this project (Table 5-3).

TABLE 5-3

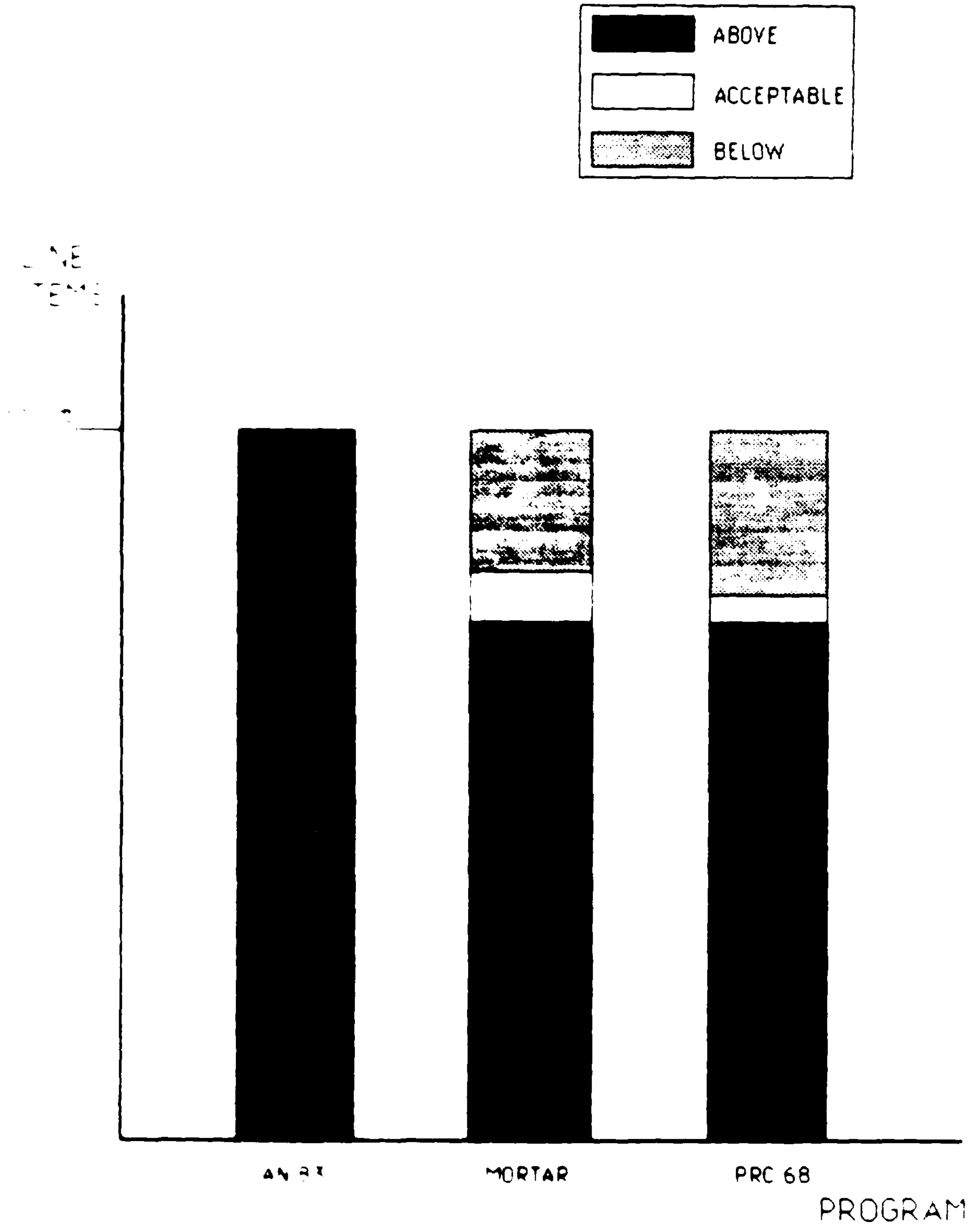
PRODUCTION LEADTIME ANALYSIS
M224 LIGHTWEIGHT COMPANY MORTAR

% OF ESTIMATES ABOVE ACTUAL PLT	% OF ESTIMATES BELOW ACTUAL PLT	% OF ESTIMATES EQUAL TO ACTUAL PLT
94.35	3.2	2.4

In no case did the estimated PLT exceed actual PLT by more than three months. In only seven cases did the contractor meet or exceed the actual PLT.

2. AN/VRC 83 (V)2 Radio Set

One hundred and eight NSN's comprised the AN/VRC-83. In every case (100%) contractor provided estimates exceeded the actual PLT maintained in the provisioning file (Table 5-4). In 49% of the NSN's considered the estimate exceeded the actual PLT by more than three months.



[illegible] Comparison of Leadtime Data

TABLE 5-4

PRODUCTION LEADTIME ANALYSIS
AN/VRC 83 (V)2 RADIO SET

% OF ESTIMATES ABOVE ACTUAL PLT	% OF ESTIMATES BELOW ACTUAL PLT	% OF ESTIMATES EQUAL TO ACTUAL PLT
100	0	0

This project had the highest rate of early deliveries/excessive estimates of the three projects.

3. <u>AN/PRC-68 Radio Set</u>

The AN/PRC-68 represented only twelve percent of the total number of NSN's considered in the analysis. In addition, it had the lowest percentage of early deliveries (or excessive estimates). Of the thirty one NSN's twenty four (77.4%) exceeded the actual PLT (Table 5-5).

TABLE 5-5

PRODUCTION LEADTIME ANALYSIS
AN/PRC 68 RADIO SET

% OF ESTIMATES ABOVE ACTUAL PLT	% OF ESTIMATES BELOW ACTUAL PLT	% OF ESTIMATES EQUAL TO ACTUAL PLT
77.4	19.4	3.2

The number of NSN's delivered more than three months earlier than expected was half of the twenty four or 50%.

C. PEACETIME REPLACEMENT RATE

One hundred and twenty eight separate FSC's representing [illegible] NSN's were considered covering a wide range of supply categories. The material ranged from weapons components, engines, valves, and radar equipment to computer devices. The equipment considered the full range of reparable items supported by the Marine Corps and administered by the ICP. Appendix [illegible] is a detailed analysis of the data. It forms the basis for the standards developed and utilized in this thesis. In addition it presents a comparison of the individual manufacturer's replacement rate to the industry standard.

Two hundred and thirty one prime contractors (manufacturers) constituted the industrial base for the analysis. For 62% of the FSC's, manufacturers provided a replacement rate lower than the industry standard. Manufacturers provided replacement rates higher than the standard in 32% of the FSC's, with the remaining 6% matching the standard.

Chapter VI discusses the results of the research and provides insight into the impact of the data presented.

VI. DISCUSSION

A. INTRODUCTION

This chapter provides the opinions, reactions and interpretations, by the researchers, of the data presented in Chapters IV and V. The researchers' opinions, however, are based on the information provided throughout this thesis.

Sections B and C consider the implications of the results of the PLT and peacetime replacement rate data, respectively.

B. PRODUCTION LEADTIME

The forecasting of PLT is instrumental in establishing when an order will be placed and for what quantity. Provisioners at the ICP generally reviewed the data provided by the contractors and adjusted it according to their best professional estimate based on their experience. Data resident in the provisioning file, then, is questionable as to whether it is actually the contractors' data or data manipulated by a government provisioner. Interviews held at the ICP indicated that once the data are manually inducted into the system there is no practical method of recapturing the original information. A comparison of PLT based on engineering and provisioners' estimates to the actual data

was conducted to verify if forecasted data reflected actual performance data.

There was a clear trend in all three projects considered, towards higher estimates than actual PLT. There are at least two reasons for overstating PLT estimates. First, by overstating PLT, manufacturers reduce the likelihood of being late in delivering the equipment. In addition, the manufacturer is perceived in a somewhat favorable light for having met or exceeded delivery schedules and, hence, provided superior supply support. Second, provisioners tend to increase requirements in an effort to improve support to the field [Ref. 27]. A general observation is that it's better to have an extra part in the event of an unforeseen circumstance.

There are at least two effects of inflated PLT. First, using higher PLT estimates than actually required causes the stockage level to increase. This is a result of increased requirements being generated by the model to compensate for longer production leadtimes. The use of a more effective model (such as ISOM) would greatly improve stockage determination levels, as discussed in Chapter III. Second, costs associated with the artificially high stockage levels (carrying costs) are higher than actually required. The government is essentially paying to carry inventory that it does not need to maintain [Ref. 30:p. 64].

The problem of inflated leadtimes is not unique to the Marine Corps. In a study conducted for the Department of Defense, the Logistics Management Institute found that file PLT was generally inflated in the Army, Navy (Aviation Supply Office), and at the Defense Industrial Supply Center. Six of the nine ICP's examined were found to have inflated PLT [Ref. 31:p. 3-5].

C. PEACETIME REPLACEMENT RATE

Replacement factors are developed by the contractor based on inherent reliability estimates. The data are provided to the provisioner for inclusion into MUMMS. Chapter II, Section E provided a detailed description of the Marine Corps' provisioning process. In order to evaluate the data provided by the manufacturer it was necessary to develop a standard, from which each manufacturer could be evaluated. The result (for each FSC) became the industry standard or base. This technique permitted comparison between an individual manufacturer's average replacement factor and the industry average.

Here again, as in the case of PLT, there was a clear trend. Our results indicated that manufacturers provided lower than average replacement rates. There are several effects of low replacement factors. If the manufacturer provides a replacement factor that is too low, the stockage level will be lower. The provisioning of too little support increases the probability of a stockout, which can be costly

in terms of time, material and personnel. On the positive side, lower inventories decrease inventory carrying costs. In addition, a low replacement factor would be favorably considered when it came time to award a contract. If the manufacturer's replacement factor is, in fact, lower than the industry standard, the government would benefit from a part that is more reliable (requires less frequency of replacement) than what is available within the industry.

Provisioners have no guide from which they can evaluate manufacturers' data. The availability of a manual of standard replacement rates would prove an invaluable tool. The manual would not serve as a substitute for historical data or engineering estimates. It would, however, serve as a point of reference from which outliers could be readily identified and pertinent questions raised. Appendix G was developed with this in mind.

In Chapter VII the researchers will present their conclusions, recommendations and answers to the research questions identified in Chapter I.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Much has been said in the past few years about the high cost of spare parts procurement. The Department of Defense and military services continue to make great progress toward rectifying this problem. A lesser publicized but potentially greater problem exists with initial provisioning of spare parts. Even inexpensive equipment procured in large quantities can be expensive. On the other hand, too few spares can reduce a weapon system's availability to dangerously low levels. Identifying the variables that influence the provisioning process is required in order to achieve the proper mix of spare parts.

Many factors influence the accuracy of determining initial provisioning requirements. Even the best provisioning models are ineffective without timely, accurate and available data.

Marine Corps provisioners need forecasts in order that long range plans for replenishment and maintenance of system operational availability can be performed. Although the data provided by contractors, and amended by provisioners, is necessary to forecast initial stock levels, there is no standard form which to validate the information.

Our research indicates manufacturers tend to provide replacement factors lower than the industry standards developed herein. There is no solid evidence why this is the case. However, conversations with Marine Corps provisioners indicate that manufacturers come in with low quotes in an effort to secure the contract. The nature of the provisioning process makes this difficult to prove. Presently, there is no method or standard available that can easily compare contractor supplied replacement data to historical data maintained on similar items previously procured.

Production leadtime is another variable that lends itself to a high degree of variability. Our research reveals that production leadtimes provided by companies tend to be higher than actual data indicates. A major cause of high production leadtimes is the contractors hesitance to stock raw materials to produce a product prior to being awarded a contract. Also, the use of inappropriate leadtimes generates higher stockage levels which needlessly ties up funds, warehouse space and manpower.

The introduction of judgment into the provisioning process is necessary. The capabilities of the people who deal with the system are important. Unless they are convinced that the system is sound, they may make little use of the information provided. The current provisioning process gives provisioners a free hand in amending variables

submitted by contractors. However, there is no way of identifying contractor information from provisioner amended data. Original manufacturer's estimates are then lost. This makes it difficult to measure a contractor's provisioning technical documentation accuracy. The possibility also exists for errors to occur when computing initial spare quantities.

The Marine Corp's current provisioning models are unable to compute realistic stockage levels. Technological advancements make the manual system outdated and inefficient. In addition, the manual process is incapable of providing the same weapon system availabilities that computer generated models can.

B. RECOMMENDATIONS

The development of a standard peacetime replacement factor handbook for use by appropriate personnel would be beneficial as an aid to decision making. Provisioners could compare contractor provided data with the standards for similar items previously procured in order to identify data outliers. Appendix G is developed by the researchers, and with the aid of Major William Johnson, U.S.M.C. (office of the Deputy Commander for Logistics, MCLB, Albany) for this study and could by expanded and updated as appropriate.

Production leadtime forecasts should be based on historical experience as a general operating rule. The ability to alter this data should be limited whenever and

wherever possible. A separate data element should be reserved for provisioners to amend contractor estimates vice the direct alteration of the contractor provided data.

The Marine Corps should quickly move toward computerization of their provisioning process. Current requirements determining methods are outdated and ineffective. MCLB Albany and CNA studies have shown that the ISOM model is able to meet the requirements currently established by the Department of Defense [Ref. 27: p. iii]. Additionally, upgrades to the model can be made as DOD provisioning policies change.

C. ANSWERS TO RESEARCH QUESTIONS

1. Are the factors used for calculating range and depth for wholesale stock adequate? The factors used in determining stockage levels are adequate [Ref. 31]. For the most part, these factors are identical to all the provisioning models used by the services today. Based on the research conducted, the ICP is maintaining stockage levels in accordance with DOD directives.

2. Can other service's provisioning techniques benefit current Marine Corps practices? In the case of the present Marine Corps manual system, any provisioning model now being used by the Navy would be an improvement. However, the ISOM model developed to replace the manual system provides essentially the same protection levels as the Navy's provisioning models.

3. Is contractor furnished provisioning data sufficient for determining procurement quantities? It is important to remember that the contractor is only responsible to provide that information specified in the contract. Therefore, it is incumbent upon the Marine Corps to ensure that all provisioning requirements are identified and clearly stated in the contract. Although the information provided by manufacturers is sufficient, the validity of the data

must be questioned. Implementation of a manual of standard factors for similar items would enhance the decision making process. Additionally, published standards will remove some of the guess work that now takes place in the Marine Corps provisioning process.

4. Does contractor forecasted provisioning data reflect actual performance and usage data? Contractor provided information did not reflect their actual performance. In 98.5% of the line items analyzed contractor PLT is above or below actual performance. In 62% of the line items analyzed for the peacetime replacement factor companies are below the industry standard.

   Inflated PLTs can cause artificially high stockage levels with their associated increased costs. The government is essentially paying for inventory that it does not need to maintain.

   The use of low peacetime replacement rates reduce stockage levels. If the spare part is less reliable than expected, the result is an increased probability of stockout. If, however, the part is reliable as forecasted, the government benefits from lower inventory costs.

5. How can the current scope and methodology of provisioning at MCLB Albany be improved? While this may seem an open ended question, two areas need to be concentrated on. The first deal with reviewing the factors that make up a provisioning model's variables. This research has only stressed two; leadtimes and replacement factors. The other revolves around the numerous provisioning models available to the Marine Corps.

   It is our opinion that the use of a standard replacement rate would prove an invaluable asset. The manual would not serve as a substitute, but as a point of reference from which the provisioner can evaluate contractor supplied data.

   Continued tests need to be conducted to identify the "best" provisioning model available for use by Marine Corps personnel. The use of a more effective model, such as ISOM, would greatly improve stockage level determination in the provisioning process.

APPENDIX A

ABBREVIATIONS/ACRONYMS

For the purpose of this thesis the following abbreviations apply:

ACG	Acquisition Coordinating Group
ACIM	Availability-Centered Inventory Model
ADT	Administrative Delay Time
Ao	Operational Availability
APO	Acquisition Project Officer
APS	Acquisition Program Sponsors
ASPO	Acquisition Sponsor Project Officer
AVCAL	Aviation Consolidated Allowance List
CNA	Center for Naval Analyses
DC	Development Coordinator
DPO	Development Project Officer
DOD	Department of Defense
DLA	Defense Logistics Agency
DLSC	Defense Logistics Service Center
DLSIE	Defense Logistics Studies Information Exchange
DODI	Department of Defense Instruction
DON	Department of the Navy
DTC	Design to Cost
DTIC	Defense Technical Information Center
FMF	Fleet Marine Force
FMSO	Fleet Material Support Office
FSC	Federal Supply Class
GOL	Garrison Operating Level
HQMC	Headquarters, United States Marine Corps
HSC	Hardware Systems Command
ICP	Inventory Control Point
IOC	Initial Operating Capability

IOT&E	Initial Operational Testing and Evaluation
IMM	Integrated Materiel Manager
ISOM	Initial Spares Optimization Model
LDT	Logistics Delay Time
LOR	Level of Repair
LORA	Level of Repair Analysis
LSA	Logistics Support Analysis
LSAR	Logistics Support Analysis Record
LWC	Lightweight Company mortar
MAF	Marine Amphibious Force
MCLB	Marine Corps Logistics Base
MCDEC	Marine Corps Development and Education Command
MCO	Marine Corps Order
MDT	Maintenance Down Time
MFRR	Maintenance Float Replacement Rate
MILSTD	Military Standard
MILSTRAP	Military Standard Transaction Reporting and Accounting Procedures
MIME	Multi-Item, Multi-Echelon Inventory Model
MIP	Material Issue Point
Mpt	Mean Preventative Maintenance Time
MTBF	Mean Time Between Failures
MTBM	Mean Time Between Maintenance
MUMMS	Marine Corps Unified Materiel Management System
NAVSUP	Navy Supply
NSN	National Stock Number
NSO	Numeric Stockage Objective
O&MC	Operations and Maintenance Marine Corps
OSP	Other Services Programs
OST	Order Ship Time
OWRMR	Other War Reserve Material Requirement
PC	Procurement Cycle
PCLT	Procurement Leadtime
PESA	Provisioning Engineering Support Activity
PFP	Program Forecast Period

PFP	Program Financial Plan (Chapter IV)
PIO	Provisioned Item Order
PICA	Primary Inventory Control Activity
PLT	Production Leadtime
PMC	Procurement Marine Corps
PPL	Provisioning Parts List
PSICP	Program Support Inventory Control Point
PTB	Program Time Base
PTD	Provisioning Technical Documentation
PWRMR	Propositioned War Reserve Material Requirement
RCT	Repair Cycle Time
RDT&E	Research, Development Test and Evaluation
RFI	Ready For Issue
RR	Repair Rate
RSR	Resupply Rate
SAIP	Spares Acquisition Integrated with Production Program
SM&R	Source, Maintenance and Recoverability
SYSCOM	System Command
TWAMP	Time-Weighted Average Monthly Program
USMC	United States Marine Corps
WRM	War Reserve Material
WS/EM	Weapon System/Equipment Management Directorate

APPENDIX B

DEFINITION OF TERMS

Availability. A measure of the degree to which an item is in the operable and committed state at the start of the mission, when the mission is called for at a random point in time [Ref. 23:p. D-1].

Consumable Supplies. Materiel which, after issue, is chemically or physically altered to the extent that it cannot be economically reused for its original purpose and/or which is not normally returned to a storage or industrial activity for repair [Ref. 25:p. A-1].

Corrective Maintenance. The replacement or repair of an item that has failed in order to restore that item to specified standards [Ref. 23:p. D-1].

Criticality. A relative measure of the consequences of a failure mode and its frequency of occurrence [Ref. 23:p. D-2].

Critical Low Density (CLD) Item. Items requiring special management attention due to extremely low density or high operational availability requirements [Ref. 25:p. A-2].

Demand. An indication of a requirement (requisition, request, issue, etc.) for issue of serviceable materiel [Ref. 25:p. A-2].

Demand Development Period. A control period of time used to accumulate demand history to justify computation of stock levels [Ref. 25:p. A-2].

Depot Level Reparables. Items whose disposition, recoverability and disposal rest with the Depot Level (5th Echelon) Maintenance facility [Ref. 25:p. A-2].

Depot Maintenance. That maintenance, required to return unserviceable equipment to a serviceable condition by repair, overhaul, or rebuild. In addition, modifications, fabrication, assembly, technical assistance, preservation, materiel inspections and evaluations, calibrations, and on-the-job training to develop and maintain proficiency for Marines is conducted at this level [Ref. 23:p. D-3].

Depth. The quantity of stocked items [Ref. 25:p. A-2]. See also range.

End Items. A final combination of end items, component parts, and/or materials which is ready for its intended use, for example tanks, jeeps and rifles [Ref. 25:p. A-3].

Expendable Supplies. All consumable and repair parts, regardless of price, and other items of supply not defined as nonexpendable property [Ref. 25:p. A-3].

Failure. An unsatisfactory condition or deviation of the condition or performance capability of an item from its new state that is unsatisfactory to a particular operating organization [Ref. 23:p. D-4].

Failure Rate. The total number of failures within an item population, divided by the total number of life units expended by that population during a particular measurement interval under stated conditions [Ref. 23:p. D-5].

Field Level Reparables. Items whose disposition, recoverability, and disposal rest with echelons of maintenance below the depot level (5th echelon) [Ref. 25:p. A-3].

Initial Issue Provisioning. A subset of initial provisioning that includes the range and quantity of items required for initial operating stock and PWRMR [Ref. 25:p. A-4].

Initial Provisioning. The process that establishes the range and quantity of initial support items required to support an end item from the time it is placed in service until full responsibility for support can be assumed by the supply system through routine replenishment [Ref. 25:p. A-4].

Intermediate Maintenance. Maintenance that is the responsibility of designated maintenance activities in support of using units. Intermediate maintenance consists of repair, calibration, emergency manufacture, and replacement of parts, components, or assemblies [Ref. 23:p. D-6].

Intermediate Maintenance Activity. The activity that performs in direct support of using units (see Intermediate Maintenance) [Ref. 25:p. A-4].

Maintainability. The measure of the ability of an item to be retained in or restored to a specified condition when maintenance is performed by personnel having specified skill levels and using the prescribed level of maintenance and repair [Ref. 23:p. D-8].

Maintenance. The function of sustaining materiel in an operational status and restoring it to a serviceable condition [Ref. 23:p. D-8].

Maintenance Float. End items or components of equipment authorized for stockage at installations for replacement of unserviceable items when immediate repair of the unserviceable item cannot be accomplished at the lowest level of maintenance [Ref. 25:p. A-5].

Maintenance Levels. The basic levels of maintenance into which all maintenance activity is divided. The scope of maintenance performed within each level must be commensurate with the personnel, equipment, technical data, and facilities provided [Ref. 23:p. D-9].

Maintenance Planning. The process conducted to evolve and establish maintenance concepts and requirements for a materiel system. It is one of the principal elements of Integrated Logistics Support (ILS) [Ref. 23:p. D-9].

Maintenance Time. An element of downtime which excludes modification and delay time [Ref. 23:p. D-9].

Materiel Issue Point (MIP). An optional consumer-level of inventory primarily limited to consumable stock under the operational control of the appropriate combat service support element [Ref. 25:p. A-6].

Mean-Time-Between-Failure (MTBF). A basic measure of reliability for repairable items. The mean number of life units during which all parts of the item perform within their specified limits during a particular measurement interval under stated conditions [Ref. 23:p. D-9].

Mean-Time-Between-Maintenance (MTBM). A measure of reliability taking into account maintenance policy. The total number of life units expended by a given time, divided by the total number of maintenance events due to that item [Ref. 23:p. D-10].

Mean-Time-To-Repair (MTTR). A basic measure of maintainability. The sum of corrective maintenance times at any specific level of repair divided by the total number of failures within an item repaired at that level, during a

particular interval under stated conditions [Ref. 23:p. D-10].

Nonexpendable Supplies. Materiel which is not chemically or physically altered with use to the extent that would preclude economical reuse for its original purpose. Nonexpendable supplies do not lose their identity in the process of work or in the rendering of services [Ref. 25:p. A-6].

Nonreparable. An item which cannot be economically restored to a serviceable condition (usually expendable items) [Ref. 25:p. A-6].

Operating Level. The quantity of materiel required to sustain operations during the interval between arrival of successive replenishment shipments [Ref. 25:p. A-6].

Operating Stock. That portion of the total quantity of an item on hand which is designated to meet the day-to-day use requirement of the stockage objective [Ref. 25:p. A-6].

Operational Readiness. The ability of a military unit to respond to its operation plan upon receipt of an operations order [Ref. 23:p. D-11].

Order and Shipping Time (OST). The time elapsing between the initiation of stock replenishment action for a specific activity and the receipt of the materiel [Ref. 25:p. A-6].

Order and Shipping Time Level. That portion of the total operating level quantity which covers the OST of replenishment requisitions [Ref. 25:p. A-7].

Organizational Maintenance. Maintenance which is the responsibility of and performed by the using organization on its assigned equipment (normally minor repairs) [Ref. 23:p. D-11].

Peacetime Replacement Factor. The total number of times per month, for all end items in use, that an unserviceable item is expected to be replaced with a serviceable item during peacetime [Ref. 20:p. 4-5].

Prepositioned War Reserve (PWR). That portion of total war reserve stocks which is positioned against a PWR requirement [Ref. 25:p. A-7].

Prepositioned War Reserve Materiel Requirements (PWRMR). That portion of war reserve materiel requirements (WRM) which approved defense guidance dictates be reserved and positioned at or near the point of planned use or issue to the user prior to hostilities, to reduce reaction time and to assure timely support of a specific force/project until replenishment can be effected [Ref. 25:p. A-7].

Preventative Maintenance. Periodic prescribed inspection and servicing of equipment accomplished on an age/usage basis (scheduled). It is usually concerned with wearout failure [Ref. 23:p. D-11].

Production Leadtime. The time from receipt of the order by the supplier to the receipt of the item into the inventory [Ref. 4:p. 57].

Protected Levels. That portion of authorized onhand stocks not authorized for issue unless certain criteria are met [Ref. 25:p. A-8].

Provisioning Control Date. The date 2 years after the in-service date of a new item at which initial issue provisioning stock levels may be adjusted to reflect actual usage [Ref. 25:p. A-8].

Purpose Code. A code assigned to materiel within the supply system which provides the user with a means of identifying the reason for which an inventory balance is reserved [Ref. 25:p. A-8].

Range. In determining stock levels, the number of different types of items stocked, regardless of quantity [Ref. 25:p. A-8]. See also depth.

Recoverable Item. An item which normally is not consumed in use and is subject to repair or disposal [Ref. 25:p. A-8].

Reliability. The probability that an item will perform its intended function for a specified period under stated conditions [Ref. 23:p. D-11].

Reorder Point. That point at which time a stock replenishment requisition would be submitted to maintain the predetermined stockage objective [Ref. 25:p. A-8].

Repair Cycle. The stages through which a reparable item passes from the time of its removal or replacement until it is reinstalled or placed in stock in a serviceable condition [Ref. 25:p. A-8].

Repair Cycle Time (RCT). The time normally required for an item to pass through the repair cycle, excluding any extraordinary delay waiting for parts and any intentional extended transit, storage or repair process delays [Ref. 25:p. A-9].

Repair Rate (RR). The fractional quantity of maintenance failure rate anticipated to be repaired each month. In the absence of empirical data a 90 percent RR is used [Ref. 25:p. A-9].

Reparable Item. An item which can be reconditioned or repaired (economically) for reuse when it becomes unserviceable [Ref. 25:p. A-9].

Requisition Objective. The maximum quantity of materiel to be maintained onhand and on order to sustain current operations [Ref. 25:p. A-9].

Source, Maintenance and Recoverability Codes (SMR). Codes used by all services to indicate maintenance and supply instructions to the various logistics support levels. These codes will promote interservice and integrated materiel support within the services. SMR codes are assigned to each support item based on the logistics support planned for the end item and its components [Ref. 25:p. A-12].

Stockage Objective. The maximum quantities of materiel to be maintained onhand to sustain current operations [Ref. 25:p. A-12].

Supply System Stock. Wholesale and retail stock in the distribution system under control of Marine Corps components for ultimate sale or issue to users [Ref. 25:p. A-12].

Table of Authorized Materiel (TAM). A listing of items (class I, II, III, VII and VIII) of materiel authorized for use by Marine Corps units [Ref. 23:p. D-13].

Unreleased Provisioning Project. Initial provisioning stock not yet released to support new equipment to be placed in the field [Ref. 25:p. A-12].

Unserviceable. An item in a condition unfit for use but which can be restored to a serviceable condition after repair, rework or overhaul [Ref. 25:p. A-12].

Weapon System. A final combination of subsystems, components, parts and materiels that make up an entity utilized in combat, either offensively or defensively,

to destroy, injure, defeat or threaten the enemy [Ref. 23:p. D-14].

Wholesale Inventory. An inventory over which an inventory manager at the national level has asset knowledge and exercises unrestricted asset control to meet worldwide inventory management responsibilities [Ref. 25:p. A-12].

APPENDIX C

MIL-STD-1388-1A

MIL-STD-1388-1A constitutes the basic standard for the logistics support analysis (LSA). The LSA program includes 15 basic tasks that can be categorized into five basic areas. These include (1) program planning and control, (2) mission and support systems definition, (3) preparation and evaluation of alternatives, (4) determination of logistic support resource requirements, and (5) supportability assessment. For the purposes of further understanding, these 15 tasks are described below [Ref. 4:pp. 428-431].

1. **Task 101-Development of an early logistic support analysis strategy.** This task identifies the anticipated technical and program task requirements for the early stages of system acquisition.

2. **Task 102-Logistic Support Analysis Plan (LSAP).** LSAP is designed to identify and integrate all LSA tasks, identify management responsibilities and activities, and outline the approach to be employed in accomplishing analysis tasks.

3. **Task 103-Program and design reviews.** This task establishes the requirement to conduct reviews to evaluate the system/subsystem design in terms of supportability characteristics.

4. **Task 201-Use study.** Identifies and documents supportability factors related to the intended use of the system/equipment. The output of this task leads to the definition of the system maintenance concept and the identification of support alternatives.

5. **Task 202-Mission hardware, software, and support system standardization.** This task defines

supportability and related design constraints for the system based on existing and planned logistic support resources.

6. **Task 203-Comparative analysis.** Selects and develops a "baseline comparison system" representing the characteristics of the new system/equipment for (1) projecting supportability related parameters, making judgments concerning the targets for improvement; and (2) determining the supportability, cost and readiness drivers for the new system/equipment. This includes the identification of quantitative measures for operation and support cost, logistic support resources, reliability and maintainability, human factors, safety ,and so on.

7. **Task 204-Technological opportunities.** The purpose is to identify and establish design technology approaches, and technological advancements, to achieve supportability improvements in the new system.

8. **Task 205-Supportability-related design factors.** Establishes (1) quantitative supportability characteristics resulting from alternative design and operational concepts; and (2) supportability and supportability-related design objectives, goals and thresholds for the new equipment.

9. **Task 301-Functional requirements identification.** Identifies the operations and support functions that must be performed for each system/equipment alternative that is being considered.

10. **Task 302-Support system alternatives.** The purpose of task 302 is to establish feasible support system alternatives for the new system/equipment configuration being considered.

11. **Task 303-Evaluation of alternatives and trade-off analysis.** Determines the preferred support system alternative for each system alternative, and participates in detailed subsystem trade-offs. The level of repair analysis is accomplished during this task.

12. **Task 401-Task analysis.** Analyzes required operations and maintenance tasks for the new system/equipment to (1) identify logistic support resource requirements for each task; (2) identify new or critical logistic support resource requirements; (3) identify transportability requirements; (4) Identify support requirements which exceed established goals,

thresholds, or constraints; (5) provide data to support participation in the development of design alternatives, reduce operation and support costs, optimize logistic support resource requirements, or enhance readiness; and (6) provide source data for preparation of required ILS documentation.

13. **Task 402-Early fielding analysis.** This task deals with the effects of the new system on the existing capability in the field.

14. **Task 403-Post-production support analysis.** Analyzes the life-cycle support requirements of the new system prior to closing the production lines to assure that adequate logistic support resources will be available during the systems remaining life.

15. **Task 501-Supportability test, evaluation, and verification.** Assesses the achievement of specified supportability requirements, identifies reasons for deviations form projections, and identifies methods of correcting deficiencies and enhancing system readiness.

APPENDIX D

MIL-STD-1388-2A

MIL-STD-1388-2A defines the logistic support analysis record (LSAR). The LSAR includes 14 individual data records pertaining to some of the technical characteristics of the system/equipment being developed. The data items relating directly to system supportability are included. The listing below provides a description of the information contained in each record [Ref. 4:pp. 434-437].

1. **Data Record A-Operations and maintenance requirements.** Included in this data record are the anticipated system operational requirements, the environment in which the system is to be operated and maintained and system maintenance requirements. Specific data factors include operational availability (Ao), achieved availability (Aa), and mean time between failure (MTBF).

2. **Data Record B-Item reliability and maintainability characteristics.** Describes the functions of the item being analyzed, and the maintenance concept to be utilized for design and support planning purposes. Additionally, the data record summarizes the reliability and maintainability design characteristics.

3. **Data Record B1-Failure mode and effects analysis.** Identifies failure modes, failure probabilities, causes of failures and compensating provisions for the system/equipment being developed.

4. **Data Record B2-Criticality and maintainability analysis.** Performs a criticality and maintainability analysis to determine the ranking of failures in terms of combined severity and the anticipated probability of occurrence. Specific data include failure rates and data source, failure severity code, criticality code, and recommended maintenance tasks to be performed.

5. **Data Record C-Operation and maintenance task summary.** Data record C consolidates the operations and maintenance tasks identified for each significant repairable item, and identifies the major support equipment required for maintaining the system.

6. **Data Record D-Operation and maintenance task analysis.** This task provides a sequential description of operations and maintenance tasks, task times and frequency, personnel quantities and skill levels, and support requirements.

7. **Data Record D1-Personnel and support requirements.** Identifies the personnel, training, support equipment, and supply support requirements for the tasks described in data record D.

8. **Data Record E-Support equipment and training material description and justification.** The objective is to consolidate information related to support equipment/test equipment requirements, associated test programs, and/or training material requirements.

9. **Data Record E1-Unit under test and automatic test.** Identifies the units under test (UUT) which will be removed from the system, and which will require off-line support/test equipment. Specific data requirements include a description of the units requiring test equipment, estimated frequency of tests, and the parameters to be measured.

10. **Data Record F-Facility description and justification.** Data record F describes and justifies all proposed special or additional facility requirements. Included in this record is a description of facility requirements, facility design criteria, procurement and installation leadtimes, and facility cost information.

11. **Data Record G-Skill evaluation and justification.** Describes and justifies any new or modified personnel skill classifications required to support the system/equipment.

12. **Data Record H-Support items identification.** Identifies static parts (nonapplication dependent) in support of spare parts screening and provisioning. Specific data include a description of component parts, part numbers and stock numbers, application, quantity per end item, procurement leadtime and unit cost.

13. **Data Record H1-Support items identification (application related).** This data record identifies large repairable items and application data for the component parts identified in data record H. Data elements include maintenance rates, repairability data (repair cycle time, turnaround time, and level of repair), and provisioning factors.

14. **Data Record J-Transportability engineering characteristics.** Identifies transportation requirements and transportability criteria of the system/equipment being designed.

APPENDIX E

SAIP PROCEDURES [Ref. 20]

1. Item Selection Criteria

a. The SAIP is intended to be applied to selected reparables and consumables which are judged to benefit from the consolidation of orders to support both production and spares requirements. The SAIP is appropriate when the following criteria are met:

(1) The economies of scale achieved by combining spares orders with installation orders substantially exceeds any added administrative costs. As a general rule, this will limit application to reparable items and selected high cost consumables.

(2) The item has been screened to ensure that Government-owned assets have been considered in computing net provisioning requirements.

(3) Risk of design obsolescence is manageable.

b. Items subject to SAIP include those in support of:

(1) Production of the end items.

(2) Initial requirements.

(3) Replenishment requirements.

(4) Foreign military sales requirements.

(5) War reserve requirements.

(6) Life-of type buys.

2. Acquisition From Prime Contractors Versus Subcontractors. The SAIP may be used in procurement from prime contractors or through direct procurement from subcontractors who are design control activities. The subcontractor is the preferred source for obtaining materiel to be provided under SAIP procedures because of the expectation of prime contractor surcharges. It is recognized, however, that exigency, configuration stability and control, cost factors, and available contractual arrangements with the prime contractor and subcontractors can

influence the decision to acquire materiel from the prime contractor or the subcontractor.

3. Timing or Orders and Tradeoff Analyses

a. Production ordering occurs periodically. The timespan which affords the opportunity to order additional quantities at the same time as the production quantities are ordered is referred to as the "ordering window." Prime contractors shall be required to furnish the Government with the ordering windows for SAIP items. This becomes the basis for timing orders for other requirements. If, in order to time spare or repair parts orders to coincide with the production ordering window, it becomes necessary to order earlier than a procurement leadtime away from when the materiel is needed, a tradeoff analysis must be made. If the advantages of combining production outweigh the disadvantages, SAIP should be employed.

b. The tradeoff analysis must consider the following:

(1) The unit price and extended price of a SAIP order versus separate orders for production quantities and spares.

(2) The cost to order (those costs associated with the determination of requirements, processing of a purchase request, and subsequent contract actions through receipt of the order into the inventory control point's system) associated with a TWAMP order versus separate orders for production quantities and types.

(3) Any additional inventory holding costs resulting from payment or delivery of materiel before it is needed.

(4) Any special surcharges associated with SAIP.

(5) Any other pertinent factors.

4. Contracting and Negotiations

a. It is preferable to include SAIP requirements in the request for proposal for full scale development. The primary advantages are these:

(1) The acquisition is still in a competitive mode.

(2) It offers an early commitment to a SAIP spares strategy.

(3) It allows competing contractors to use this leverage with their subcontractors, thereby enhancing the potential for combining installation and spares orders when the production lines are open.

b. When developing the contractual instruments to implement SAIP the following considerations should be included in contractual coverage clauses:

(1) The contract shall require that the contractor combine materiel orders and manufacturing actions for spares and items to be installed on the system or subsystem when ordered to do so by the Government.

(2) The contract shall require that the contractor provide data to verify that pricing of items for production installation and spares is uniform and consistent. This data will be utilized in determining application of SAIP for follow-on procurement.

(3) Configuration control shall be maintained for on-order spares as well as for items to be installed during production of the primary system or subsystem. Contractual language shall be utilized which assures that:

(a) Unusable items are not procured.

(b) Contractors identify any Government orders which are subject to configuration change, to enable review and possible adjustment of the order.

(4) In order to preclude additional inventory holding costs that might result from delivery of spares before they are needed, a contractual clause requiring that the contractor deliver the spares concurrent with the supported end item may be used.

c. When applying SAIP direct from subcontractors, the following additional steps must be followed:

(1) The prime contract must contain provisions for identification of the design control activities early enough in the production cycle to allow separate negotiation of SAIP requirements.

(2) The prime contractor's installation order schedule must be available to the Government sufficiently in advance to properly time the processing of SAIP orders.

(3) SAIP orders placed with the subcontractor must contain clauses that ensure that items are delivered in the

same configuration as the items obtained under the prime contractor's installation orders.

d. When applying SAIP with the prime contractor.

(1) The contract shall require the prime contractor to ensure that orders for items manufactured by subcontractors are placed directly with the last organization to add value to the item through either a manufacturing or inspection process. For this action, the prime may add an administrative charge to each SAIP order. The contract shall not allow any other charge to be added by the prime except for handling, packaging, and testing costs associated with the delivery as a spare part.

(2) For spares, the prime contractor shall be held responsible for monitoring the manufacturer's production or procurement schedules and for delivering that information to the prime provisioning activity. In addition, the prime shall be held responsible for ensuring that the asset is always delivered in the appropriate configuration.

5. Cost Avoidance Verification. It is of considerable interest to acquisition and funds managers to know the value of SAIP in avoiding unnecessary costs. However, quantitative techniques are not available currently to establish auditable savings resulting from SAIP. The reason for this is that under SAIP the contractor is contractually committed to providing spares at the negotiated price; it is merely a speculation as to what the negotiated price might have been, had SAIP not been applied. The contractor may be asked for an estimate of the price for separate, unconsolidated orders, but without the registration process and resultant contract, cost benefits of SAIP can only be estimated. Nevertheless, it is still desirable to develop estimates of benefits. Seek to obtain estimates of the prices of orders if they had not been consolidated with production orders, and to maintain the capability to estimate the total cost benefit of SAIP for their programs. However, caution should be exercised to avoid expenditure of significant resources on the part of either the Government or contractors for the sole purpose of developing precise cost avoidance determinations.

APPENDIX F

INITIAL SYSTEM STOCK OPERATING LEVEL (PROVISIONING REQUIREMENTS OBJECTIVE)[Ref. 20]

Marine Corps-Managed	Consumables 90 days (PC) plus PCLT 1/ 2/ 3/ 4/ 5/	Reparables 90 days (PC) plus PCLT 1/ 2/ 3/ 4/ 5/
Integrated Management by Other Services/Agencies 6/	Not Authorized	

1/ When the computed 90-day PC initial provisioning requirements quantity for an already established Marine Corps-managed item is considered significant, the demand base for that item will be increased by the provisioning estimate; and RO will be recalculated. The provisioning estimate will be based on a 90-day PC only, and not include PCLT.

2/ If computations fail to authorize stockage, a limited quantity of Critical Code 1 items may be stocked for insurance purposes only (SSC A). However, if the item is stocked as an insurance item at the retail level, no system stock is authorized. Insurance items may be stocked at retail or wholesale level, but not at both levels.

3/ When computing initial system stock requirements, an analysis will be performed to determine if a cost savings can be realized through the use of an economic-buy-quantity.

4/ NSO items may be stocked as retail and system stock.

5/ Initial system stock of Marine Corps-managed items will be protected from disposal during the 2-year demand development period. If, at the end of the 2-year period, an item so protected has had no usage, the protection period will be extended an additional 2 years.

6/ An IMM is a single agency which exercises total DoD management responsibility for a Federal supply group/class, commodity, or item.

APPENDIX G

ANALYSIS OF THE PEACETIME REPLACEMENT RATE CONTRACTOR TO INDUSTRY STANDARD

Federal Supply Class (FSC)	FSC Average Peacetime Replacement Factor	Manufacturer's Code	Manufacturer's Average Peacetime Replacement Factor
1005 Guns, through 30mm	.532		
		13160	0.737
		95270	0.300
		01365	0.129
		53711	0.087
		62983	0.042
		19200	0.000
1010 Guns Over 30mm up to 75mm	.135		
		19206	0.174
		53711	0.105
		19200	0.040
1015 Guns, 75mm through 125mm	.261		
		19207	0.500
		53711	0.022
1025 Guns, Over 150mm through 200mm	.200		
		19206	0.200
		19200	0.166
		19204	0.144
055 Launchers, Grenade, Rocket, and Pyrotechnic	.030		
		81361	0.030

1220 Fire Control Computing sights and equipment	.750		
		80058	0.750
1240 Optical Sighting and Ranging Equipment	.218		
		19200	0.224
		13160	0.217
		01365	0.210
		53711	0.040
		10237	0.032
1260 Fire Control Designating and Indicating Equipment	.398		
		18876	0.398
1270 Aircraft Gunnery Fire Control Components	.460		
		98453	0.460
1280 Aircraft Bombing Fire Control Components	.100		
		72737	0.100
1290 Miscellaneous Fire Control Equipment	.529		
		07690	2.445
		19200	0.163
		80063	0.001
1370 Pyrotechnics	.033		
		53711	0.033
1420 Guided Missile Components	.386		
		18876	0.386

1430 Guided Missile Remote Control Systems	.466		
		28876	1.100
		99479	1.000
		11876	0.685
		18876	0.470
		27963	0.050
		82059	0.002
1560 Airframe Structural Components	.521		
		18876	0.521
1650 Aircraft Hydraulic, Vacuum, and Deicing System Components	.100		
		96906	0.100
2320 Trucks and Truck Tractors, Wheeled	.100		
		56161	0.100
		75078	0.068
		19207	0.003
2330 Trailers	.001		
		19207	0.001
2350 Combat, Assault, and Tactical Vehicles, Tracked	.167		
		53711	0.167
2510 Vehicular Cab, Body, and Frame Structural Components	.025		
		80064	0.025
2520 Vehicular Power Transmission Components	.097		
		56161	0.648
		73342	0.237

		12603	0.196
		78500	0.165
		45152	0.158
		19207	0.093
		11862	0.066
		80064	0.048
		34635	0.036
		34623	0.029
		11083	0.023
		90192	0.006
		99167	0.001
2530 Vehicular Brake, Steering, Axle, Wheel, and Track Components	.056		
		80064	0.059
		78500	0.032
		27401	0.020
		99167	0.001
2540 Vehicular Furniture and Accessories	.008		
		80064	0.009
		19207	0.006
2590 Miscellaneous Vehicular Components	.028		
		56161	0.086
		80064	0.019
		53711	0.015
		96259	0.003
		11083	0.001
2805 Gasoline Reciprocating Engines, Except Aircraft and Components	.100		
		19207	0.100
2815 Diesel Engines and Components	.120		
		20263	1.000
		56161	0.970
		72582	0.249
		15434	0.165
		30554	0.152

		19207	0.120
		13446	0.100
		24617	0.100
		80064	0.095
		11862	0.090
		34623	0.039
		50022	0.024
		97907	0.020
		11083	0.007
		01365	0.003
2910 Engine Fuel System Components, Non-aircraft	.085		
		84760	0.137
		06504	0.100
		56161	0.100
		53711	0.040
		15434	0.036
2920 Engine Electrical System Components, Non-aircraft	.074		
		35510	0.178
		80064	0.104
		19207	0.035
		53711	0.032
2930 Engine Cooling System Components, Non-aircraft	.120		
		92857	0.140
		15434	0.020
2940 Engine Air and Oil Filters, Strainers, and Cleaners, Non-aircraft	.800		
		53711	0.800
2950 Turbo-superchargers	.008		
		08179	0.008

2990 Miscellaneous Engine Accessories, Non-aircraft	.022		
		15434	0.298
		80064	0.022
3010 Torque Converters and Speed Changers	.119		
		03538	0.421
		19204	0.123
		80063	0.070
		80064	0.013
		53711	0.008
		54547	0.001
3020 Gears, Pulleys, Sprockets, and Transmission Chain	.070		
		19204	0.108
		80063	0.100
		98738	0.016
3040 Miscellaneous Power Transmission Equipment	.013		
		01238	0.040
		80063	0.020
		80064	0.015
		10237	0.010
		90192	0.001
3110 Bearings, Antifriction, Unmounted	.350		
		87990	0.350
3130 Bearings, Mounted	.021		
		12115	0.021
3431 Electrical Arc Welding Equipment	.005		
		50740	0.008
		28835	0.003

3940 Blocks, Tackle, Rigging, and Slings	.100		
		56161	0.100
3990 Miscellaneous Materials Handling Equipment	.002		
		52555	0.003
		29381	0.002
4020 Fiber Rope, Cordage, and Twine	.071		
		87959	0.130
		33875	0.013
4140 Fans, Air Circulators, and Blower Equipment	.009		
		82877	0.020
		56996	0.004
4230 Decontaminating and Impregnating Equipment	.012		
		97942	0.030
		81361	0.003
4310 Compressors and Vacuum Pumps	.110		
		55612	0.203
		30760	0.023
		99251	0.020
		15434	0.003
		56161	0.003
4320 Power and Hand Pumps	.193		
		56161	0.297
		18876	0.100
		80064	0.074
		15434	0.045
		97403	0.021
		13160	0.016

4710 Industrial Boilers	.004		
		81349	0.004
4730 Fittings and Specialities; Hose, Pipe, and Tube	.281		
		80064	0.281
4810 Valves, Powered	.106		
		91816	0.158
		56161	0.100
		80064	0.016
4820 Valves, Non-powered	.039		
		18876	0.100
		15434	0.073
		80064	0.070
		53711	0.009
		99251	0.007
4910 Motor Vehicle Maintenance and Repair Shop Specialized Equipment	.250		
		70167	0.250
4931 Fire Control Maintenance and Repair Shop Specialized Equipment	.037		
		18876	0.037
4933 Weapons Maintenance and Repair Shop Specialized Equipment	.206		
		19206	0.220
		12906	0.005

4935 Guided Missile, Maintenance, Repair, and Checkout Specialized Equipment	.630		
		82577	2.685
		90230	2.000
		18878	1.500
		98453	1.500
		18876	0.252
		27963	0.050
		96214	0.030
4940 Miscellaneous Maintenance and Repair Shop Specialized Equipment	.500		
		53711	0.500
5305 Screws	.008		
		28687	0.008
5365 Rings, Shims, and Spacers	.308		
		19206	0.373
		19200	0.030
5410 Prefab and Portable Buildings	.010		
		80063	0.010
5411 Rigid Wall Shelters	.002		
		80058	0.002
5805 Telephone and Telegraph Equipment	.507		
		49956	4.231
		80063	0.662
		33783	0.525
		87990	0.460
		81349	0.420
		80058	0.267
		24384	0.200
		25512	0.166
		01534	0.133
		80372	0.010

		56996	0.005
		20183	0.001
5810 Communications Security Equipment and Components	.333		
		02227	2.532
		80058	0.034
		98230	0.008
5811 Other Cryptologic Equipment and Components	.433		
		14632	0.500
		98230	0.400
5815 Teletype and Facsimile Equipment	.171		
		58634	0.835
		18876	0.625
		54418	0.190
		80063	0.153
		12813	0.150
		62768	0.053
		15230	0.050
		15755	0.050
		19790	0.042
		80058	0.005
		96214	0.001
5820 Radio and Television Communication Equipment, Except Airborne	.168		
		18876	1.500
		56996	1.300
		05159	0.980
		37695	0.762
		80058	0.369
		20183	0.332
		81349	0.325
		13499	0.281
		83744	0.236
		23386	0.232
		10412	0.185
		14305	0.150
		90536	0.150
		14304	0.139

		80063	0.117
		87990	0.113
		00724	0.102
		25512	0.100
		80249	0.100
		98738	0.090
		49671	0.087
		14632	0.085
		94990	0.063
		80372	0.061
		55044	0.053
		15870	0.050
		14203	0.046
		72737	0.033
		12436	0.010
		31160	0.010
		33783	0.010
		81348	0.010
		12115	0.007
		09680	0.004
		11447	0.004
		96341	0.004
		32791	0.003
		88044	0.003
		05157	0.001
5821 Radio and Television Communication Equipment	.672		
		13499	0.674
		75378	0.550
5825 Radio Navigation Equipment, Except Airborne	.067		
		99479	0.200
		80063	0.079
		04274	0.020
		57958	0.010
		05869	0.001
		80058	0.001
		80103	0.001
		81590	0.001
		91723	0.001
5826 Radio Navigation Equipment, Airborne	.035		
		80063	0.035

5830 Intercom-munication and Public Address Systems, Except Airborne	.052		
		80063	0.321
		18876	0.100
		80045	0.026
		80058	0.014
		80064	0.013
5831 Intercom-municational and Public Address Systems, Airborne	.060		
		80058	0.060
5835 Sound Recording and Reproducing Equipment	.081		
		98230	0.400
		29422	0.200
		07342	0.061
		28687	0.050
		15942	0.040
		80058	0.010
5840 Radar Equipment, Except Airborne	.842		
		34874	5.350
		09087	2.677
		12115	2.207
		97942	1.996
		08484	1.750
		07649	1.250
		87990	0.669
		57761	0.611
		03538	0.598
		94990	0.400
		31260	0.362
		17773	0.300
		57257	0.284
		01238	0.159
		08569	0.140
		05869	0.122
		80586	0.100
		05286	0.090
		80063	0.060
		03526	0.056

		19059	0.051
		14345	0.050
		25512	0.050
		80058	0.039
		11716	0.036
		01584	0.030
		05876	0.029
		25223	0.022
		56977	0.020
		27125	0.015
		11263	0.010
		05157	0.007
		31106	0.004
		50264	0.004
		57946	0.004
		04155	0.003
		58691	0.003
		49671	0.001
5845 Underwater Sound Equipment	.033		
		97525	0.350
		31160	0.054
		92059	0.002
5855 Night Vision Equipment, Emitted and Reflected Radiation	.373		
		99251	0.987
		80058	0.436
		80063	0.361
		18876	0.056
5860 Stimulated Coherent Radiation Devices, Components, and Accessories	.158		
		80063	0.176
		80058	0.086
5865 Electronic Countermeasures, Counter-Countermeasures, and Quick Reaction Capability Equipment	.034		
		97525	0.150
		80063	0.050

		57761	0.033
		94990	0.019
		80058	0.005
5895 Miscellaneous Communication Equipment	.222		
		13973	0.802
		14482	0.500
		57761	0.467
		13499	0.440
		51859	0.363
		80058	0.345
		15755	0.300
		94990	0.267
		90536	0.201
		11627	0.172
		03538	0.162
		29355	0.150
		12813	0.141
		49671	0.116
		96238	0.113
		18876	0.100
		14632	0.096
		24930	0.086
		31260	0.086
		80063	0.063
		62768	0.053
		19905	0.050
		19790	0.040
		98738	0.040
		09004	0.031
		54418	0.030
		73293	0.029
		14203	0.025
		96214	0.020
		05869	0.011
		91417	0.011
		12115	0.010
		24539	0.010
		54616	0.010
		80372	0.008
		04932	0.007
		57946	0.006
		97942	0.004
		09017	0.003
		32097	0.003
		93738	0.002
		21847	0.001
		28687	0.001
		56996	0.001
		57958	0.001

5905 Resistors	.097		
		96214	0.500
		80372	0.050
		80373	0.030
		94990	0.001
5910 Capacitors	.066		
		02304	0.300
		90536	0.100
		13499	0.050
		80372	0.020
5915 Filters and Networks	.200		
		37695	0.850
		34657	0.840
		57761	0.700
		18876	0.671
		80063	0.332
		51859	0.247
		23386	0.232
		03538	0.225
		94990	0.050
		80372	0.037
		00724	0.035
		13499	0.020
		39671	0.020
		80045	0.013
		91417	0.005
		33783	0.003
		01456	0.001
		03526	0.001
5930 Switches	.139		
		18876	0.421
		03538	0.313
		04643	0.050
		12115	0.040
		98738	0.029
		53711	0.023
		90536	0.022
		80058	0.020
		16250	0.010
		56996	0.004
5935 Connectors, Electrical	.016		
		03538	0.022
		80064	0.010

5940 Lugs, Terminals, and Terminal Strips	.006		
		80058	0.013
		49671	0.004
		80064	0.002
5945 Relays and Solenoids	.069	80064	0.120
		30554	0.081
		96214	0.036
		14203	0.035
		12115	0.002
5950 Coils and Transformers	.230	53854	1.200
		18876	1.033
		56977	0.140
		14304	0.080
		13499	0.050
		94990	0.050
		80063	0.045
		14632	0.010
5955 Oscillators and Piezoelectric Crystals	.061		
		18876	0.100
		49671	0.004
		97942	0.003
5960 Electron Tubes and Associated Hardware	.359		
		97942	2.500
		01238	0.320
		18876	0.100
		80063	0.096
		99313	0.004
5961 Semiconductor Devices and Associated Hardware	.250		
		23426	0.500
		12115	0.001

5962 Micro-circuits, Electronic	.547		
		13499	0.928
		62768	0.053
		06481	0.005
		56977	0.001
		91417	0.001
5963 Electronic Modules	.051		
		18876	0.100
		80063	0.040
		49671	0.005
		83744	0.004
5965 Headphones, Handsets, Micro-phones, and Speakers	.040		
		80058	0.070
		80372	0.010
5985 Antennas, Waveguide, and Related Equipment	.235		
		03538	1.150
		87990	0.750
		37695	0.700
		13499	0.584
		80372	0.130
		18876	0.100
		14304	0.080
		31637	0.050
		33875	0.046
		04953	0.041
		80063	0.040
		98738	0.020
		80058	0.019
		12115	0.017
		88419	0.010
		00724	0.005
		74041	0.005
		97942	0.005
		57958	0.002
		00443	0.001
		09017	0.001
		51025	0.001
		57946	0.001
		82152	0.001

5990 Synchros and Resolvers	.192		
		80372	0.500
		18876	0.150
		06481	0.010
5995 Cable, Cord, and Wire Assemblies; Communication Equipment	.039		
		03538	0.521
		24655	0.500
		56996	0.300
		13499	0.186
		00724	0.050
		12115	0.050
		87990	0.050
		27963	0.045
		13973	0.042
		05869	0.041
		99872	0.026
		53711	0.019
		97942	0.019
		80064	0.016
		90536	0.010
		80058	0.008
		33875	0.007
		57946	0.003
		80063	0.003
		01365	0.002
		20183	0.001
5999 Miscellaneous Electrical and Electronic Components	.327		
		27963	3.841
		02304	1.128
		97942	1.085
		18876	1.023
		14632	1.000
		57761	0.743
		94990	0.627
		03538	0.563
		56996	0.549
		17773	0.543
		24655	0.500
		13973	0.388
		23426	0.340
		13160	0.332
		80372	0.311

		87990	0.251
		13499	0.246
		37695	0.172
		14304	0.150
		53711	0.122
		80212	0.100
		28480	0.099
		03526	0.079
		80064	0.076
		01238	0.053
		62768	0.053
		98781	0.050
		97871	0.048
		99251	0.040
		28687	0.038
		05157	0.030
		24930	0.025
		80063	0.023
		80045	0.020
		19207	0.014
		06481	0.007
		57946	0.005
		49671	0.004
		54418	0.001
6105 Motors, Electrical	.071		
		07860	0.370
		87990	0.323
		18876	0.100
		53711	0.090
		80063	0.054
		27963	0.050
		97403	0.030
		58634	0.020
		64731	0.015
		13160	0.010
		96214	0.010
		54418	0.008
		25223	0.004
		92059	0.001
6110 Electrical Control Equipment	.003		
		49671	0.958
		03538	0.608
		80063	0.323
		30554	0.230
		00724	0.220
		18876	0.099
		02304	0.064

		13160	0.054
		96214	0.051
		13973	0.050
		53711	0.050
		80064	0.020
		80058	0.015
		19207	0.006
		97942	0.003
		20183	0.001
6115 Generators and Generator Sets, Electrical	.058		
		28835	0.100
		80064	0.088
		30554	0.062
		12670	0.040
		80058	0.010
		93568	0.007
		12532	0.005
6125 Conductors, Electrical, Nonrotating	.300		
		03538	0.700
		04155	0.700
		18876	0.100
6130 Converters, Electrical, Nonrotating	.419		
		12115	8.000
		97942	2.083
		04879	1.000
		03538	0.745
		57761	0.700
		01365	0.500
		13065	0.500
		13973	0.500
		80063	0.420
		03526	0.328
		13499	0.271
		33783	0.216
		49671	0.128
		90536	0.123
		00724	0.100
		18876	0.100
		06481	0.050
		31160	0.050
		72737	0.050
		04643	0.040
		83744	0.035

		19059	0.015
		94990	0.013
		05869	0.010
		04932	0.007
		09062	0.005
		80058	0.005
		57946	0.004
		97871	0.003
		85604	0.002
		09004	0.001
6145 Wire and Cable, Electrical	.237		
		80063	0.237
6150 Miscellaneous Electric Power and Distribution Equipment	.059		
		98437	2.500
		12813	0.047
		56161	0.040
		80064	0.022
		53711	0.018
		04932	0.010
		81349	0.001
6615 Automatic Pilot Mechanisms and Airborne Gyro Components	.20		
		14632	0.400
		94990	0.001
6620 Engine Instruments	.007		
		96309	0.173
		15434	0.001
6625 Electrical and Electronic Properties Measuring and Testing Instruments	.320		
		97942	6.000
		98453	1.005
		14632	1.000
		53431	1.000

		05869	0.959
		01365	0.500
		97384	0.500
		24655	0.462
		80058	0.449
		89536	0.389
		03538	0.375
		80009	0.318
		27963	0.307
		12115	0.279
		98738	0.270
		20944	0.250
		37695	0.150
		64842	0.150
		55044	0.127
		49671	0.107
		18876	0.100
		00063	0.100
		31557	0.050
		73446	0.040
		49956	0.020
		28480	0.012
		90536	0.010
		80372	0.009
		11332	0.008
		31935	0.003
		06481	0.002
		25512	0.002
		50440	0.001
		57958	0.001
6630 Mechanisms and Components	.20		
			0.400
		94990	0.001
6635 Electronic Components	.087		
		96309	0.173
		15434	0.001
6640 Electronic Wiring and Testing	.320		
		97942	6.000
		98453	1.005
		14632	1.000
		53431	1.000
		05869	0.959
		01365	0.500
		97384	0.500

		24655	0.462
		80058	0.449
		89536	0.389
		03538	0.375
		80009	0.318
		27963	0.307
		12115	0.279
		98738	0.270
		20944	0.250
		37695	0.150
		64842	0.150
		55044	0.127
		49671	0.107
		18876	0.100
		80063	0.100
		19905	0.085
		01534	0.072
		31160	0.050
		31557	0.050
		73446	0.040
		49956	0.020
		28480	0.012
		90536	0.010
		80372	0.009
		11332	0.008
		31935	0.003
		06481	0.002
		25512	0.002
		50440	0.001
		57958	0.001
6645 Time Measuring Instruments	.025		
		81349	0.050
		13499	0.001
6650 Optical Instruments	.248		
		98453	0.757
		18876	0.600
		19206	0.228
		12115	0.004
		57946	0.001
6660 Meteorological Instruments and Apparatus	.005		
		15476	0.053
		57946	0.003

		63848	0.001
		80058	0.001
6675 Drafting, Surveying, and Mapping Instruments	.045		
		80372	0.262
		14668	0.150
		06481	0.018
		96214	0.010
		06175	0.008
		63848	0.001
6680 Liquid and Gas Flow, Liquid Level, and Mechanical Motion Measuring Instruments	.100		
		56161	0.100
6685 Pressure, Temperature, and Humidity Measuring and Controlling Instruments	.990		
		79172	4.004
		18876	1.500
		19905	0.057
6695 Combination and Miscellaneous Instruments	.013		
		92434	0.013
6740 Photographic Developing and Finishing Equipment	.008		
		96214	0.008
6780 Photographic Equipment and Accessories	.022		
		97525	0.216
		83744	0.193
		96214	0.170
		54418	0.156
		27963	0.102
		72737	0.040

		86360	0.036
		56496	0.027
		04643	0.010
6920 Armament Training Devices	.875		
		18876	0.875
7010 ADPF System Configuration	.109		
		90536	0.138
		80058	0.021
7021 ADP Central Processing Unit (Digital)	.166		
		13973	0.186
		12115	0.168
		15476	0.053
		05869	0.014
		27963	0.001
		96214	0.001
7022 ADP Central Processing Unit (Hybrid)	.042		
		04643	0.042
7025 ADP Input/ Output and Storage Devices	.084		
		24655	0.100
		54418	0.201
		80058	0.217
		14668	0.109
		90536	0.091
		19059	0.060
		15476	0.053
		03538	0.050
		27963	0.050
		80063	0.023
		96214	0.017
		12115	0.015
		96215	0.010
7035 Film, Processed	.088		
		31160	0.208
		87990	0.065
		90536	0.050

		80058	0.015
		96214	0.010
7040 Punched Card Equipment	.50		
		90536	0.500
7045 ADP Supplies	.230		
		57761	0.230
7050 ADP Components	.355		
		97942	2.500
		13499	0.472
		03538	0.269
		95105	0.100
		90536	0.032
		80063	0.020
		80058	0.010
		91417	0.010
8110 Drums and Cans	.001		
		18876	0.001
8120 Commercial and Industrial Gas	.412		
		80063	0.412
8140 Ammunition and Nuclear Ord Containers	.250		
		80372	0.250
8145 Specialized Shipping and Storage Containers	.020		
		80064	0.020

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